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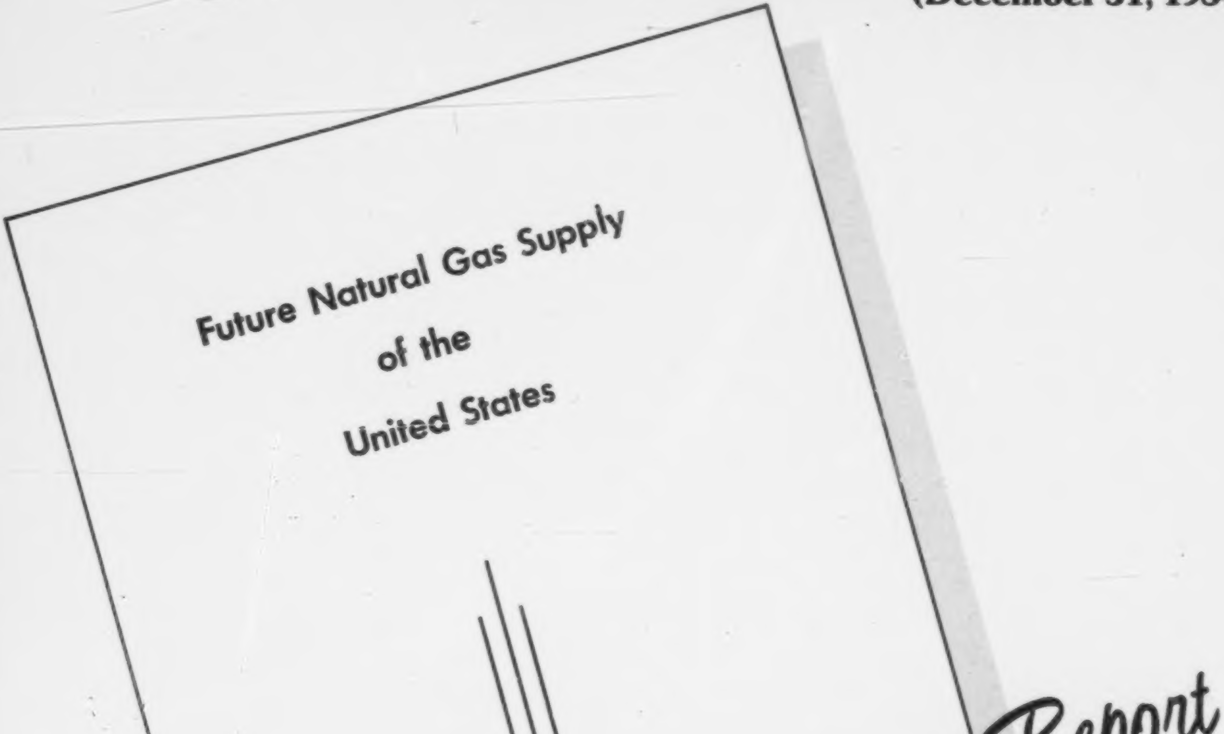
POTENTIAL SUPPLY OF NATURAL GAS IN THE UNITED STATES

(December 31, 1984)



Future Natural Gas Supply
of the
United States

20th Anniversary Report

Prepared by the
Future Gas Supply Committee
Volume No. 1
October, 1964

Potential Gas Committee
Potential Gas Agency

Colorado School of Mines
Golden, Colorado 80401

The Potential Gas Committee comprises volunteer members from the natural gas industry, government agencies, and academic institutions who are concerned with natural gas resources.

The Committee functions independently but with the guidance and assistance of the Potential Gas Agency of the Colorado School of Mines. The Potential Gas Agency is supported by the American Gas Association.

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POTENTIAL SUPPLY OF NATURAL GAS IN THE UNITED STATES

(December 31, 1984)

Report of the Potential Gas Committee
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Potential Gas Agency
Colorado School of Mines

June 1985

PREFACE

The objective of the Potential Gas Committee is to provide estimates, based upon expert knowledge, of the potential supply of natural gas which, in conjunction with estimates of proved reserves of natural gas, make possible an appraisal of long-range gas supply.

For many years, estimates of future supply of natural gas have been developed by numerous individuals and organizations. Since these estimates of future supply have varied widely and often have had entirely different objectives and meanings, they have served to confuse rather than to clarify the long-range outlook for natural gas supply. With the view toward achieving a more unified industry-sponsored effort, many leaders of the natural gas industry, as well as various financial and governmental agencies, sought a longer-range, ongoing, study of the requirements and supply of natural gas in the United States. As a result of this concern, the work of the Potential Gas Committee was initiated in 1960. The Committee, in early years known as the Future Gas Supply Committee, has functioned since that time and has prepared regular reports presenting estimates of the recoverable natural gas which is believed to exist in addition to proved reserves. Since 1967 the work of the Committee has been guided and assisted by the Potential Gas Agency of the Colorado School of Mines.

This 20th Anniversary Report of the Potential Gas Committee includes many changes from earlier reports. Discussions of the geology and the natural gas potential are presented for each of the geographic areas included in 87 geologic provinces of the lower 48 states and Alaska. Fifty-four of these geologic provinces are in onshore areas and 33 are offshore. This change represents a considerable increase in detail over the 12 onshore areas and 12 offshore areas used in recent reports. The earlier practice is continued of giving, for each of the onshore provinces, separate estimates for (1) resources estimated to occur at drilling depths of less than 15,000 feet and (2) those estimated to occur at drilling depths between 15,000 and 30,000 feet. Offshore provinces are separated into those that occur beneath water depths of less than 200 meters (continental shelf) and those that occur beneath water depths of 200 to 1,000 meters (upper continental slope).

Additionally, resource estimates for each geologic province are given in terms of maximum, most likely, and minimum estimates instead of only the most likely estimate which had been the basis of reporting in the past. The Potential Gas Committee believes that this new manner of reporting will give users a better understanding of the uncertainty involved in the resource estimate for any one province. In keeping with greater detail, both in province reporting and in the ranges of estimates, most resource estimates in this report are expressed in terms of billion cubic feet (Bcf) of estimated natural gas resource potential.

The cumulative changes which have been made in the reports of the Potential Gas Committee over the years are vividly highlighted by the contrast of this 1984 report with the original 1964 report of the Future Gas Supply Committee which is reproduced in its entirety on pages vi to viii.

DEDICATION

B. WARREN BEEBE

The Potential Gas Committee is honored to dedicate this report to B. Warren Beebe, who, as one of the founders of the Committee, contributed greatly to the success of both the organization and its series of reports. Warren's devotion to his chosen profession of geology and his strength in overcoming personal physical handicaps stand as an inspiration to all who follow after him.

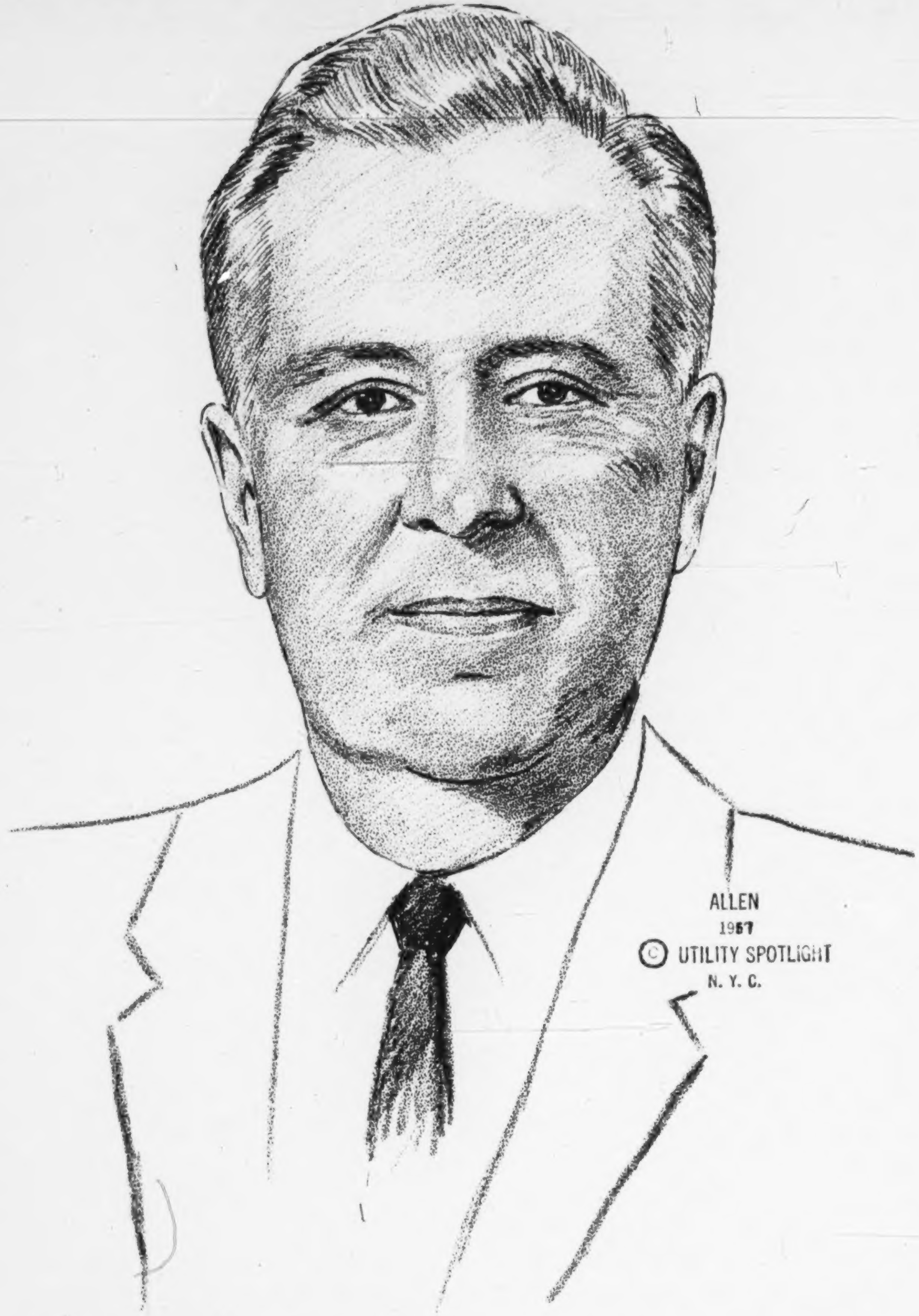
Byron Warren Beebe was born July 25, 1913, in Udall, Kansas. His academic training was taken at both the University of Wichita in Wichita, Kansas, and the California Institute of Technology in Pasadena, California. After his studies in Wichita he worked in the petroleum industry in the Mid-Continent area of the United States and also in the Illinois basin and in north Texas. He continued this work after Cal Tech, but also expanded his horizons to the Rocky Mountain region, the Michigan basin, west and south Texas and beyond the U.S. borders to Mexico and Canada. From 1950, he worked largely as an independent consulting geologist and geophysicist drawing on his wide experience in exploration for oil and gas.

Warren's professional zeal and his desire to share his knowledge with others led to numerous publications. Notable is the landmark Memoir 9 of The American Association of Petroleum Geologists, "Natural Gases of North America," published in 1968. He was also co-editor of A.A.P.G. Memoir 2, "Backbone of the Americas."

He has been active in most professional associations of U.S. geologists. Among other honors, he is a Fellow of the American Association for the Advancement of Science and of the Geological Society of America, and an honorary member of the American Association of Petroleum Geologists, the Oklahoma Geological Society and the Rocky Mountain Association of Geologists.

Warren was stricken with multiple sclerosis at the height of his career, but, in spite of the crippling effect of this disease, he continued to work hard at his profession and to devote much of his life to helping others, especially encouraging young geologists to contribute to their profession. As an independent consultant, he did not have the financial backing of an employer to support his work on the Potential Gas Committee, but gave of his own resources to further the work which he felt to be of greater imporance than any he might have been doing for personal financial gain.

The members of the Potential Gas Committee take this opportunity to express their sincere thanks to Warren Beebe for his long service to the Committee and to his chosen profession.


ALLEN
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A Report of the
Future Natural Gas Supply
# of the
United States

Volume No. 1
October, 1964

Published by the
Future Gas Supply Committee
P. O. Box 308
Omaha, Nebraska

Report of the
Future Gas Supply Committee

This is the initial report concerning the future natural gas supply of the United States made by this Committee.

The future natural gas supply of the United States available under circumstances existing today, but excluding proven reserves is estimated to be (trillion cubic feet):

East	109.8
Central	442.5
West	77.2
TOTAL	629.5

The above supply figures do not include the 276.15 trillion cubic feet of natural gas reserves classified as proven by the A.G.A. Committee on Natural Gas Reserves, as of December 31, 1963. Thus, the estimated total natural gas supply in the United States at the present time is in excess of 905 trillion cubic feet.

Scope and Purpose

The leaders of the natural gas industry have expressed a strong desire for a continuing long-range study of the requirements and supply of the natural gas in the United States. Many have made predictions concerning the gas requirements and the gas supply of the future. None has made a thorough nationwide study using the efforts and judgment of competent representation from all phases of the industry. The time has now come for industry to appraise its own future.

The intent of this work is to utilize the knowledge and experienced judgment of the best informed people in all segments of the industry. No group or organization is better equipped or qualified to evaluate the potential of the industry—than the industry itself.

This report in no way intends to set out a plan or course of action for the industry. Instead, it is a fact-finding effort to assist management in "looking down the road."

Description of the Project

This is a summary of supply data provided by transmission and production companies throughout the entire nation and is the first step in a long-range look at the future of our industry.

The responsibility of this committee has been to develop estimated future supplies of gas in the United States. Its members are comprised of representatives from producing and pipeline companies. Many major companies have assigned highly competent men to serve on this committee. These men are expert in their field of work and have joined efforts in obtaining the best available data upon which to judge the future supply of gas. The studies will not, in any way, duplicate or replace the valuable and authoritative work by the A.G.A. Natural Gas Reserves Committee—in fact, they augment and complement the vital work now being done by that committee.

It is also our intention to extend this work into Canada and Mexico. After all, if we are to attempt to look into the future, we must begin to determine the total gas potential that may have an impact upon the gas supply situation for the future.

The work of the committee and the established goals can only be accomplished by continuing to make further studies in the future. This will be done. Each revision in the future will permit us to profit from the experience of the preceding report — to add more and more up-to-date information — and to evaluate the impact of varying factors that will influence the estimates. Future refinement of statistical data and improvement in techniques, will provide the industry with additional valuable information upon which we can build an even more solid foundation — upon which can rest the confidence that our industry will move forward. It will allow us to make available the facts for those who will have management responsibilities for the establishing of policies of today with regards to the fullfilment of the objectives of tomorrow.

Acknowledgment

It is appropriate to give detailed acknowledgments in this, the first report of the Future Gas Supply Committee.

Appreciation and thanks go to the personnel of the Committee for their outstanding work. On behalf of this Committee, appreciation is extended to all of the many companies who have been so willing to supply us with confidential information.

The work was greatly intensified when Warren Beebe, a nationally known geologist and geophysicist, accepted the job of Chairman. His broad knowledge and experience in gas and oil field work made him an excellent leader to guide the work of this group.

Significant aid in all aspects of the work was given to us by Mark Burlingame, Executive Vice President of Natural Gas Pipeline Company of America. His long and varied experience in the gas business, which includes all phases of the industry, made it possible for him to serve as an excellent Technical Advisor.

A great deal of credit goes to V. R. Swanson of Northern Natural Gas Company, Committee Coordinator, who has done most of the statistical and coordinating work connected with this project.

We have had very capable assistance from Harold S. Walker, Jr., Assistant Managing Director of A.G.A., who has served as the Secretary of the Committee. He has provided a continuing liaison in all segments of the work.

We were extremely fortunate that Lyon Terry of Lehman Bros., New York, a nationally eminent geologist and economist, helped us organize this committee. He spent a great deal of time helping us by talking with the many producing companies—encouraging them to take an interest in the work by supplying competent men to serve on the committee. Without his help, this work would have been greatly delayed.

Appreciation and thanks are extended to the many major oil companies, independent producers and pipeline companies who have furnished committee members and subcommittee members for this work.

Larry Shomaker, Chairman
Future Gas Requirements and
Supply Committee

50 YEARS AGO

Development of Project

In the early part of 1940 the natural gas industry saw the need to determine with as much technical accuracy and "informed judgment" as possible the reserves of gas available for commercial use in the United States. As a result, the American Gas Association Committee on Natural Gas Reserves for the United States was formed. Subsequently, the Committee's annual report was expanded to include the report of the American Petroleum Institute Committee on Petroleum Reserves (Oil) and the Canadian Petroleum Association's report on reserves of crude oil, natural gas liquids, and natural gas. For the past seventeen (17) years, a combined report on the estimated proved reserves of crude oil, natural gas liquids, and natural gas in the United States and Canada has been made. The highly authoritative work of this committee is now generally accepted as being the official estimate of the amount of proved recoverable gas reserves in the United States and Canada.

Now, two decades later, the gas industry is confronted with a question as to the *future* supply of natural gas. Highly conflicting and diametrically opposed predictions of the natural gas supply have been made over the past twenty (20) years. Some have warned us that this nation will soon run completely out of natural gas — others have assured us that there are uncounted trillions of cubic feet under the ground awaiting discovery by the mere turn of the valve.

The industry recognized this lack of agreement, and the Committee on Future Gas Requirements and Supply was established. The scope and purpose of the effort is to forecast future natural gas supply probability through the combined judgment of qualified exploration personnel from presently known proved reserves and those which can reasonably be expected to be found in the United States, Canada and

Mexico. This initial and preliminary report, however, deals only with natural gas in the contiguous United States.

A substantial part of the total amount of gas which may be ultimately available has already been found, but it took a century to do it.

It is estimated that total production of natural gas from the United States to the end of 1963 has been about 226 trillion cubic feet. Adding the approximately 276 trillion cubic feet of estimated proven reserves now in "inventory, "the industry has discovered a total of 502 trillion cubic feet of natural gas during the past century. The total amount of any natural resource is ultimately fixed by nature. But the "future available supply" and the rate at which it can be developed is a function of economic factors and technologic improvements.

Presumably the oil and gas industry has explored to varying degrees the most prospective territory for discovery of hydrocarbons. A vast amount of information concerning their occurrence, accumulation, and discovery has been compiled. Exploration, drilling, completion, and production techniques improve continuously. Considering all of these factors and the history of past estimates of available future supply of a natural resource, the Committee is convinced that continuous study of accumulating information in an orderly manner, and periodic reports, revising previous reports, is essential to provide the industry with up-to-date estimates of the future available supply of natural gas in the United States.

The work done by this committee will in no way duplicate or infringe on the valuable and commendable work by the AGA — API Reserves Committee. Instead, it will augment and extend the scope of the vital work done by the Gas Reserves Committee. This committee will, in effect, commence its work at the point where the Gas Reserves Committee completes its work.

Organization

The gas supply personnel comprise twelve members assigned to the twelve working areas of the United States, a member assigned to Canada, and a member assigned to Mexico.

(a) Each of the fourteen members representing areas of the United States, Canada, and Mexico is chairman of the subcommittee responsible for the determination of the estimated future available gas supply in his assigned area.

(b) Each subcommittee chairman is familiar with the area assigned to him.

(c) Each subcommittee chairman coordinates all information required to complete the estimated future gas supply data for his assigned area.

Each subcommittee consists of as many members as deemed necessary by the subcommittee chairman to adequately determine the estimated future available gas supply of his assigned area.

(a) Subcommittee members from both producer and pipeline companies are selected by the subcommittee chairman.

(b) Each subcommittee member is intimately familiar with the portion of the working area to which he is assigned.

General Procedures

The Committee and its subcommittees have worked continuously with private information obtained on a most confidential basis from many sources. The continuation of the Committee's important task and the value of its estimates depend on the availability of such confidential data. Each committee and subcommittee member is fully aware of and respects the confidential nature of both the data made available to him and the estimates prepared by the subcommittees and the main committee.

The Committee has met periodically at the call of the chairman at various central locations with no set schedule at this time.

Subcommittees have met and discussed their work prior to the commencement of studies and as often thereafter as deemed necessary. Each subcommittee member has initiated a study of the particular portion of the area assigned to him by using data and manpower available to him.

Upon completion of various phases of studies by subcommittee members, the subcommittees met and prepared a subcommittee report for its assigned area. Each subcommittee member has retained his own confidential working papers and only final estimates have been submitted 'to his chairman.

After completion of reports for each area, the gas supply group met and prepared a report. Subcommittee chairmen furnished only total estimates of their areas to the supply group chairman, and no working papers were made available. However, methods and results were discussed at length. The gas supply group then prepared this report.

It is anticipated that further estimates will be made and revised periodically.

20 YEARS AGO

20 YEARS AGO

Technical Approach

Future available supplies of natural gas used by this committee includes all of the natural gas in any particular area which it is believed could be found and produced under prevailing technical conditions, that over and above the estimated volume of proved recoverable reserves made by the American Gas Association Committee on Natural Gas Reserves.

The duties of the Future Gas Supply Committee carry forward from that point where the Gas Reserves Committee quite properly completes its work. Like the Gas Reserves Committee, our committee conducts an area-by-area examination by knowledgeable and qualified individuals. We feel that we thus offer the gas industry a much more precise concept of the future available natural gas supply than has been published by any other individual or group.

The technical approach to determining the future available gas supply of the United States was studied in three (3) categories—probable future supply, possible future supply, and suspected future supply. These are all inferred available future supplies and cannot be classed in any sense as reserves nor should they be confused with or referred to as such. After considerable discussion by the Committee, it was decided that in this initial report, the total future available natural gas supply of the United States would be reported as one figure—and not set out by the volume determined to be estimated for each category until such time as methods can be refined and agreement on terminology can be reached.

However, the Committee is now working on improving its technical approach so that it will be possible to use these or similar categories for future studies and plans to make future reports on the basis of two or three categories of reasonable expectancy.

Historically, the discovery of natural gas has been inextricably entwined with the discovery of oil. During the past decade as demand has increased, there has been an ever-increasing and effective directional search. Nevertheless, a substantial portion of new reserves added each year are found associated with oil and/or as a direct result of exploration with oil as the major objective. Exploration for and discoveries of new reserves of oil have been declining in the United States for almost a decade. It is a moot question whether the continuously more effective directional search will affect the amount of gas found associated with oil or as a result of exploration with oil as the major objective. Although the total proved reserves of natural gas have increased yearly, the average additions from new discoveries alone have not shown as much increase over the past ten years.

The Committees used several methods for particular areas as a test of the reliability of the estimates. Statistical, [illegible], geophysical, and geological approaches [illegible]. Some areas [illegible] to subcommittees were further divided and assigned to sub-groups by geographical and by geological divisions. The report of future gas supply is founded on the informed collective judgment of the membership.

This initial, preliminary report covers only the contiguous forty-eight (48) states (on shore and off shore), leaving Alaska and Hawaii, and Canada and Mexico to the future. Thus, it appears reasonable to [illegible] the reporting of future available supply of natural gas before embarking on more than the most preliminary phases of studies of the possibilities for coal gasification, natural gas from distillation of oil shales and tar sands, and importation of liquefied natural gas as set forth in the scope and purpose of the Committee.

Future Gas Requirements and Supply Committee

Larry Shomaker, (*Chairman*), Senior Vice President, Northern Natural Gas Company

Mark V. Burlingame, (*Technical Advisor*), Executive Vice President, Natural Gas Pipeline Company of America

V. R. Swanson, (*Committee Coordinator*), Administrative Assistant, Northern Natural Gas Company

Harold S. Walker, Jr., (*Secretary*), Assistant Managing Director, American Gas Association, Inc.

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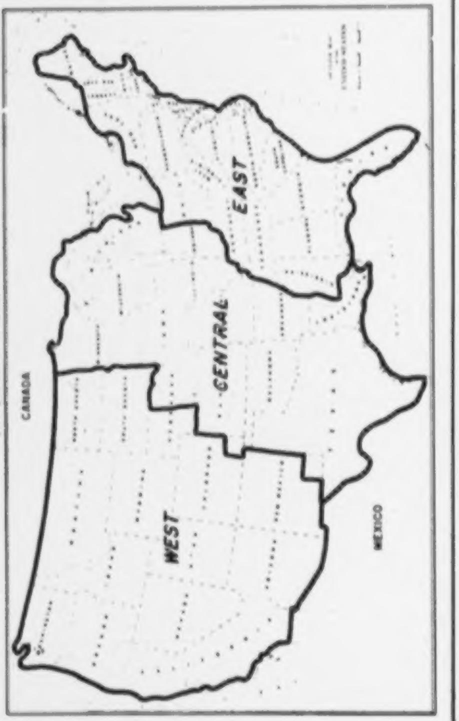
Dr. H. P. Woodward

FUTURE GAS SUPPLY COMMITTEE

GAS SUPPLY AREAS
(For publication of data)



CONTENTS

REPORT OF THE POTENTIAL GAS COMMITTEE 1
SUMMARY 1
INTRODUCTION 3
DEFINITION OF NATURAL GAS 3
CATEGORIES OF NATURAL GAS RESOURCES 4
ESTIMATION OF POTENTIAL GAS SUPPLY 8
LIMITING CONSIDERATIONS 9
Drilling Depth and Water Depth Limitations 9
Economic, Technological and Policy Considerations 11
Unconventional Resources 11
NATIONAL SUMMARY STATISTICS 12

POTENTIAL GAS COMMITTEE NATURAL GAS RESOURCE ESTIMATES 25

ATLANTIC AREA 27
P-100, New England Province and Adirondack Uplift 27
P-110, Atlantic Coastal Basin 27
P-120, Appalachian Basin 27
P-130, Piedmont-Blue Ridge Province 31
P-140, South Georgia-Peninsular Florida Sedimentary Province 31
P-150, Black Warrior Basin 33
P-910 and P-911, Atlantic Offshore, Shelf and Slope 35
P-915 and P-916, West Florida Offshore, Shelf and Slope 35

NORTH CENTRAL AREA 39
P-200, Michigan Basin 39
P-210, Cincinnati Arch 41
P-220, Illinois Basin 41
P-230, Upper Mississippi Embayment 43
P-240, Wisconsin Arch, Sioux Uplift and Iowa Shelf 43
P-250, Lincoln Anticline and Ozark Uplift 43
P-260, Forest City Basin and Cherokee Basin 43

GULF COAST AREA 47
P-300, Louisiana-Mississippi-Alabama Salt Basins 47
P-310, Louisiana Gulf Coast Basin (Onshore) 50
P-320, East Texas Basin 52
P-330, Texas Gulf Coast Basin (Onshore) 52
P-930 and P-931, Eastern Gulf Coast Offshore, Shelf and Slope 57
P-935 and P-936, Louisiana Offshore, Shelf and Slope 57
P-940 and P-941, Texas Offshore, Shelf and Slope 59

MID-CONTINENT AREA 63
P-400, Central Kansas Uplift, Salina Basin, Nemaha Anticline and Sedgwick Basin..........63
P-410, Arkoma Basin..63
P-420, Anadarko Basin, Palo Duro Basin, Amarillo Arch and Chatauqua Platform.............66
P-430, Fort Worth Basin, Bend Arch and Strawn Basin..69
P-440, Permian Basin..70

ROCKY MOUNTAIN AREA 75
P-500, Williston Basin...76
P-510, Powder River Basin...76
P-515, Big Horn Basin...79
P-520, Wind River Basin..84
P-530, Greater Green River Basin, Hanna and Laramie Basins....................................84
P-535, Denver Basin, Chadron Arch and Las Animas Arch...87
P-540, Uinta-Piceance Basin, Park Basins and Eagle Basin..87
P-545, San Juan Mountains, San Luis Basin,
Las Vegas-Raton Basin, Sierra Grande Uplift...92
P-550, Paradox Basin..94
P-555, San Juan Basin...96
P-560, Southern Basin and Range Province..96
P-565, Plateau Province and Black Mesa Basin...99
P-570, Sweetgrass Arch and Central Montana...103
P-575, Montana Folded Belt..103
P-580, Snake River Basin...105
P-590, Wyoming-Utah-Idaho Thrust Belt...105

PACIFIC AREA 111
P-600, Oregon-Washington Coastal Basins, Okanogan Province....................................111
P-610, Eastern Columbia Basin...112
P-620, Great Basin, Sierra Nevada, Klamath Mountains and Southern Oregon.................112
P-630, Southeastern California Basins..113
P-640, Sacramento Basin..113
P-650, San Joaquin Basin...113
P-660, California Coastal Basins..117
P-960 and P-961, Pacific Offshore, Shelf and Slope..119

ALASKA AREA 123
P-701, Alaska North Slope..123
P-702, Alaska Southern Foothills and Brooks Range...125
P-703, Yukon Flats Basin and Kandik Basin...125
P-704, Alaska Interior Basins...125
P-705, Northern Gulf of Alaska (Onshore)..126
P-706, Southeastern Alaska...126
P-707, Cook Inlet-Susitna Province (Onshore)...126
P-708, Alaska Peninsula-Shelikof Province (Onshore)..128
P-709, Alaska Peninsula-Bristol Bay (Onshore)...128
P-710, Aleutian Islands..128
P-971 and P-972, Beaufort Sea, Shelf and Slope...128
P-973, Chukchi Shelf..129

P-974, Norton Basin....129
P-975, Hope Basin....129
P-979, St. Matthew Basin-Bethel Basin Shelf....129
P-980, Southwest Bering Sea Slope....129
P-981 and P-982, Navarin Basin, Shelf and Slope....129
P-983 and P-984, St. George Basin, Shelf and Slope....130
P-985, Bristol Bay Basin Shelf....130
P-987 and P-988, Shumagin-Kodiak Shelf and Slope....130
P-989 and P-990, Aleutian Shelf and Slope....130
P-991, P-992, P-993 and P-994, Northern Gulf of Alaska and Southeastern Alaska, Shelf and Slope....130
P-995, Cook Inlet Basin, Offshore....130

POLICY GUIDELINES....133

GENERAL POLICY STATEMENT....133
MEMBERSHIP OF COMMITTEES AND POLICY GUIDELINES FOR COMMITTEES....133
GAS SUPPLY COMMITTEE OF THE AMERICAN GAS ASSOCIATION....135
POTENTIAL GAS AGENCY OF THE COLORADO SCHOOL OF MINES....135
POTENTIAL GAS COMMITTEE....136
AREA WORK COMMITTEES....138
STANDING COMMITTEES OF THE POTENTIAL GAS COMMITTEE....140
- Board of Directors....140
- Editorial Committee....140
- Committee on Definitions and Procedures....140
- Time and Site Committee....141

COMMUNICATIONS....141
- Communication Between Committees....141
- Public Communication....141

MEMBERSHIP OF THE POTENTIAL GAS AGENCY AND POTENTIAL GAS COMMITTEE....143

PLATES

Plate	*Title*
1	Potential Gas Committee Natural Gas Map of the United States 12/31/84....In pocket
2	Potential Gas Committee Natural Gas Map of Alaska 12/31/84....In pocket

ILLUSTRATIONS

Figure	Title
1	Categories of Past, Present and Future Natural Gas Supplies....5
2	Schematic Representation of Categories of Potential Supply....7
3	Comparison of Potential Gas Committee and U.S. Geological Survey Natural Gas Resource Classification Categories....8
4	Potential Gas Committee Work Areas and Geologic Provinces....10
5	Schematic Representation of the Relationship Between Potential Gas Committee Resource Estimates and Estimates of Natural Gas Resources in Low Permeability Formations....13
6	Cumulative Production, Proved Reserves and Potential Supply of Natural Gas in the United States....21
7	Ultimately Recoverable Resource of Natural Gas in the United States....24
8	Organization of Potential Gas Supply Studies....134

TABLES

Table	Title
1	Estimated Potential Supply of Natural Gas--Most Likely Estimates....1
2	Potential Gas Committee 1984 Estimates by Area....14
3	Potential Gas Committee 1984 Estimates--Total United States....16
4	Estimated Potential Supply of Natural Gas, Onshore, 0-15,000'....17
5	Estimated Potential Supply of Natural Gas, Onshore, 15,000-30,000'....17
6	Estimated Potential Supply of Natural Gas, Offshore, 0-200 m....18
7	Estimated Potential Supply of Natural Gas, Offshore, 200-1,000 m....18
8	Comparison of Estimates of Ultimately Recoverable Volumes of Natural Gas in the United States for Period December 31, 1966 to December 31, 1984....19
9	Comparison of Estimates of Potential Supply of Natural Gas from Potential Gas Committee Reports....20
10	Comparison of Estimates, 1982 and 1984, by Area....22
11	Estimated Resources of Natural Gas for Provinces of the Atlantic Area....37
12	Estimated Resources of Natural Gas for Provinces of the North Central Area....45
13	Estimated Resources of Natural Gas for Provinces of the Gulf Coast Area....60
14	Estimated Resources of Natural Gas for Provinces of the Mid-Continent Area....73
15	Estimated Resources of Natural Gas for Provinces of the Rocky Mountain Area....108
16	Estimated Resources of Natural Gas for Provinces of the Pacific Area....120
17	Estimated Resources of Natural Gas for Provinces of the Alaska Area....132

REPORT OF THE POTENTIAL GAS COMMITTEE

Summary

The Potential Gas Committee comprises volunteer members from the natural gas industry, government agencies and academic institutions who are concerned with natural gas resources. Members of the Committee, their experience and affiliations, are listed in the last section of this report. The Committee functions independently but with the guidance and assistance of the Potential Gas Agency of the Colorado School of Mines. The Potential Gas Agency is supported by the American Gas Association. Biennial estimates of the potential supply of natural gas have been prepared and published since 1964, with the exception of 1974.

The Potential Gas Committee's most likely estimate of the potential supply of natural gas in the United States, as of December 31, 1984, is as follows:

Table I. Estimated potential supply of natural gas--most likely estimate (billion cubic feet at 14.73 psia and 60° F.)

	Probable	Possible	Speculative
Lower 48 States			
--Onshore	143,402	199,026	163,040
--Offshore	32,256	64,813	44,028
Alaska			
--Onshore	6,700	16,400	27,690
--Offshore	2,400	12,700	71,470
Total United States	184,758	292,939	306,228

The sum of these estimates represents a most likely total resource potential of 783,925 billion cubic feet (Bcf).

The foregoing estimates represent the conventional potential supply expected to be recovered by future drilling under conditions of:

1. adequate economic incentives in terms of price/cost relationships, and
2. current or foreseeable technology.

These estimates do not assume any fixed time schedule for the discovery and production of future gas supply.

The Potential Gas Committee's estimates do not include, and are distinct and separate from, the volume of proved recoverable natural gas reserves contained in the nation's discovered fields. The relationship between proved reserves and the several categories of potential natural gas supply is illustrated in figures 2 and 3, and described in detail in the section on Categories of Natural Gas Resources.

The Potential Gas Committee's previously published estimates of potential natural gas supply (by category) in the United States as of December 31, 1982, were as follows (in trillion cubic feet): Probable 192, Possible 355, and Speculative 329.

Comparison of these totals with the new estimates presented in table 1 reveals decreases in all categories. These estimates represent, however, the current status of a dynamic system in which former potential resources pass into proved reserves and production through discovery and development of new pools and fields, and the estimates of remaining potential resources are revised based on knowledge gained through additional exploration and drilling.

Major changes in resource estimates, especially estimates of Speculative resources, most frequently occur for frontier areas, such as some offshore regions, Alaska, and portions of the Rocky Mountain states. These changes reflect the uncertainty of resource estimation where available geological and geophysical data are limited and where new exploration programs may bring about significant changes in the knowledge and interpretation of the nature and occurrence of the natural gas resource.

The estimates for the resource potential of two provinces, the Eastern Gulf of Mexico continental shelf and slope (P-930 and P-931), have been increased significantly from the 1982 estimates. Recent discoveries in this offshore area have demonstrated the probability of sizable natural gas resources within these provinces.

The resource estimates for two provinces, the Wind River basin (P-520) of Wyoming and the Wyoming-Utah-Idaho Thrust Belt (P-590) have been reduced significantly from the 1982 estimate. Relatively recent exploratory drilling has disproved some of the geologic extrapolations on which earlier resource estimates were based.

The resource estimates for a few provinces were modified based on reassessment of the resource potential as a result of new exploratory information. Changes in most other provinces were of the order expected with normal discoveries and transfers of potential resources to proved reserves. Where no change in resource estimate was made from the 1982 assessment, there was either insufficient new information or lack of exploratory activity within the province.

Introduction

The estimates of the Potential Gas Committee include recoverable "conventional" natural gas which, in the judgment of Committee members, can be recovered given adequate economic incentives in terms of price/cost relationships and utilizing current or foreseeable technology. Since these potential resources have not yet been confirmed by drilling and testing, there can be no rigorous evaluation of the economic viability of the resources. The accumulations, however, are believed to exist in concentrations which are of sufficient size and quality, considering geographic distribution and depth of occurrence, to warrant exploration and development.

Annual estimates of proved reserves of natural gas in the United States were prepared, through 1979, by the Committee on Natural Gas Reserves of the American Gas Association. Since 1977, and continuing to the present, annual estimates of proved reserves have been prepared independently by the Energy Information Administration of the U.S. Department of Energy. These estimates are, by definition, limited to those estimated proved recoverable reserves of natural gas which have been established by drilling. Such estimates do not reflect potential supplies of natural gas which may be discovered as a result of future exploratory drilling. It is the estimates of future supply which are the concern of the Potential Gas Committee and which are discussed in this report.

Previous reports of the Potential Gas Committee (1978 and 1980)[1] have included summaries, prepared by the Potential Gas Agency, of potential resource estimates for natural gas which may exist under nonconventional conditions, including gas from tight formations, Devonian shales, geopressured brines, coalbeds, and gas hydrates. A similar summary is not included with this report and the reader is referred to the previous publications for such information.

Review of the estimates of the Potential Gas Committee has indicated that a portion of the natural gas resource estimated by the Committee is believed to occur in formations which have *in situ* permeabilities to natural gas of less than 0.1 millidarcy. Such resources have been included by others in estimates of nonconventional resources and, consequently, there is partial overlap with estimates of the Potential Gas Committee. This overlap is addressed further in the section on Limiting Considerations.

Definition of Natural Gas

Natural gas, as used in this report, is any gas (at standard conditions of temperature and pressure, 14.73 psia and 60° F) of natural origin that is composed primarily of hydrocarbon molecules producible from a borehole. Most natural gas contains some nonhydrocarbon components, such as carbon dioxide, nitrogen, hydrogen sulfide and helium. In estimating potential supply, it is not feasible to separate small volumes of these components from the hydrocarbons; however, in areas where significant volumes of such nonhydrocarbons are believed to occur, only the hydrocarbon components are included in the estimated potential supply.

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[1] Potential Gas Committee, 1979, Potential Supply of Natural Gas in the United States, as of December 31, 1978: Potential Gas Agency, Colorado School of Mines, Golden, 75 p.

Potential Gas Committee, 1981, Potential Supply of Natural Gas in the United States, as of December 31, 1980: Potential Gas Agency, Colorado School of Mines, Golden, 119 p.

Categories of Natural Gas Resources

At a given time, a finite volume of natural gas exists within the rocks of the shallow portion of the earth's crust. This finite volume of gas in-place is the total natural gas resource. The amount of this resource which is recoverable is a function of technology and economics. Today, technology has advanced to the degree that a significant part of the resource base can be recovered. A major part of this resource, however, is dispersed throughout the earth's crust in such minute accumulations or under such conditions that it cannot be extracted with existing or foreseeable technology, and also because the cost of recovery of this gas is too high compared to the value of the gas. Even with likely advances in technology, production of some deposits will not be feasible because recovery of such accumulations would require more energy than that provided by the gas produced.

Estimates of the Potential Gas Committee include only the natural gas resource which can be discovered and produced using current or foreseeable technology and under the condition that the price/cost ratio will be favorable. This total quantity is referred to as the *Ultimately Recoverable Resource*. Terminology used in this report emphasizes that the Committee is presenting estimates of natural gas that it believes can be both *discovered* and *recovered* under the limiting conditions established by the Committee.

The *Ultimately Recoverable Resource* represents the quantity of natural gas expected to be produced during the life of the industry through exploration for and development of the resource. Recovery would be effected by utilizing conventional techniques of exploration, drilling, completion and production and also by incorporating new technological developments. The Ultimately Recoverable Resource includes both *discovered* and *undiscovered* natural gas resources. Discovered gas consists of the quantity which has been produced in past years plus that proved by drilling and engineering tests and included in present *Proved Reserves*. Additionally, discovered gas includes the gas, remaining in known fields, that is expected to be recovered through extension and complete development of known pools and reservoirs. The undiscovered resource consists of the potential gas supply expected to become productive upon further exploration and development and includes both the gas remaining in undiscovered pools and reservoirs within known fields and the gas that may be discovered in new fields and reservoirs, not only within provinces which are presently productive but also within provinces which are as yet unproductive.

The subdivision of Ultimately Recoverable Resource into categories reflects the variation in the amount of geological and engineering information upon which the estimate is based. Proceeding from left to right in figure 1, the level of geological and engineering knowledge decreases.

Past production, reported as cumulative production, is the total volume of natural gas withdrawn from producing reservoirs. Some uncertainty involving the amount of production from earlier years exists as a result of incomplete records, but a reasonable estimate has been made based on available information. Estimates of past production presented in this report have been prepared by the Committee on Natural Gas Reserves of the American Gas Association (AGA). Annual production for years up to 1979 was obtained from the reports of the Committee on Natural Gas Reserves.[2] Annual production for years from 1980 to the present was obtained from the reports of the Energy Information Administration (EIA) of the U. S. Department of Energy.[3]

Proved reserves are the currently estimated quantity of natural gas which analysis of geologic and engineering data demonstrate with reasonable certainty to be recoverable in the future from known oil and gas reservoirs under existing economic and operating conditions. Reservoirs are considered proved that have demonstrated the ability to produce by either actual production or conclusive formation tests. The existence and quantity of gas have been *confirmed* by

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[2] American Petroleum Institute, American Gas Association, Canadian Petroleum Association, 1979, Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada as of December 31, 1979: American Petroleum Institute and American Gas Association, Washington, D.C., 253 p. (also annual reports for preceding years).

[3] Energy Information Administration, 1984, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 1983 Annual Report: U.S. Department of Energy, Energy Information Administration, Washington, D.C., 101 p. ([DOE/EIA-0216(83)] and reports for earlier years).

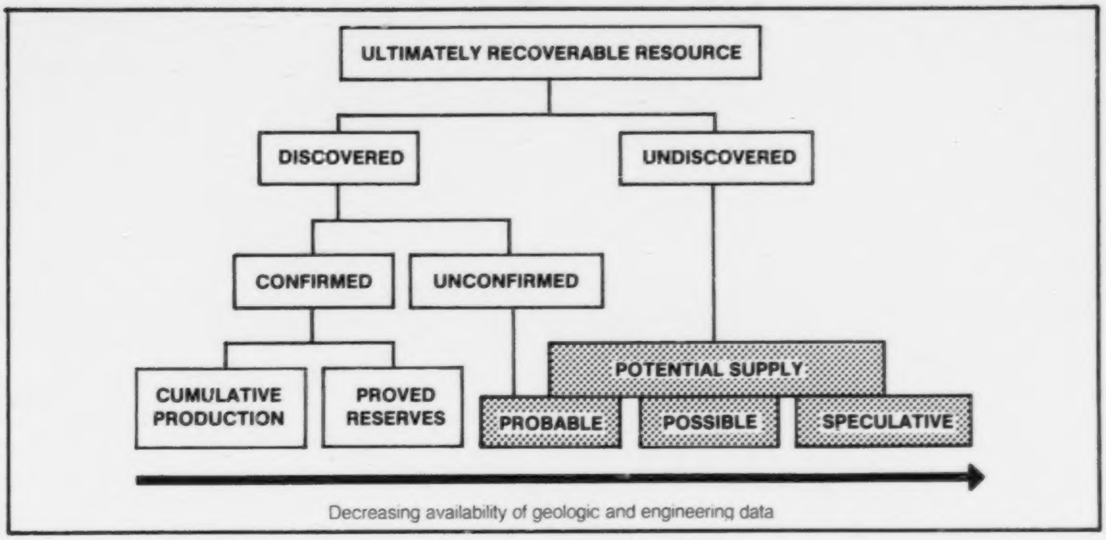

Figure 1. Categories of past, present and future natural gas supplies

testing. The Potential Gas Committee does not estimate volumes of proved reserves. Estimates of proved reserves were compiled annually from 1946 through 1979 by the Committee on Natural Gas Reserves of AGA. The AGA estimates have been largely supplanted by reports prepared by EIA which began with data for 1977 and have replaced the AGA estimates for 1980 and subsequent years.

The *Potential* supply includes the remaining discovered gas resources in addition to proved reserves and all of the undiscovered resources. The three categories of potential supply recognized and reported by the Potential Gas Committee are: Probable, Possible and Speculative, and these are differentiated on the basis of variation in available geologic information.

Probable potential gas supply is associated with existing fields. It is the most assured of potential supplies, because it is associated with known accumulations, and a relatively large amount of geological and engineering information is available to aid in estimation of the reported figures in this category. The Probable supply bridges the boundary between discovered and undiscovered resources. The discovered portion includes supply from future extensions of *existing pools* in known productive reservoirs [1].[1] The pool containing this gas has been discovered, but the extent of the pool has not been completely delineated by development drilling; therefore, the existence and quantity of gas in the undrilled portion of the pool are as yet *unconfirmed*. The undiscovered portion of Probable supply is expected to come from future *new pool* discoveries within existing fields either in reservoirs productive elsewhere in the field [2], or in shallower or deeper formations known to be productive elsewhere in the same geologic province or subprovince [3].

Possible potential supply is a less assured supply because it is postulated to exist outside of known fields, but it is associated with a productive formation in a productive province. Its occurrence is indicated by projection of plays or trends of a producing formation into a less well-explored area of the same geologic province or subprovince. Supply is from *new field* discoveries, postulated to occur within these trends or plays under both similar [4] and different [5] geologic conditions (i.e., the types of traps and/or structural settings may either be the same or differ in some aspect).

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[1] Numbers in brackets refer to accumulations shown diagrammatically in figure 2.

Speculative potential gas supply, the most nebulous category, is from formations or provinces that have not yet proven to be productive. Geologic analogs are developed in order to ensure reasonable evaluation of these unknown quantities. Supply is from *new pool* [6] or *new field* [7] discoveries in *formations not previously productive* within a productive geologic province or subprovince and from *new field* discoveries within a geologic *province not previously productive* [8].

To reiterate, the accuracy of the estimates of gas volumes included in the potential supply is dependent upon geological conditions and knowledge and the extent to which the given area has been explored and developed. By following the estimation guidelines as closely as possible, consistency and compatibility of the estimates by members of the Potential Gas Committee are maintained. However, the individual estimator may have to use slight modifications of the considerations and procedures when compiling estimates for each of the three categories because of the particular characteristics applicable to his reporting area.

Estimates of potential resources of natural gas in the United States also are made by the Resource Appraisal Group of the United States Geological Survey (USGS), whose most recently published report is USGS Circular 860[5] and includes estimates of crude oil and natural gas liquids as well as natural gas. Although resource terminology of the USGS Resource Appraisal Group differs from that used by the Potential Gas Committee, the USGS category of Undiscovered Recoverable Resources is essentially equivalent to the combined Possible and Speculative categories (fig. 3). A further discussion of the definitions and usage of USGS terminology is set forth in USGS Circular 831.[6]

Explanation for Figure 2–Schematic representation of categories of potential supply

I. Probable–Associated with existing fields–most assured,
    1) Discovered–unconfirmed: discovered trap, existing production elsewhere in the trap [1]
    2) Undiscovered: undiscovered trap, productive formation–supply from new pool discoveries within existing field in
        a) reservoir producing within the same field [2]
        b) shallower or deeper formations producing elsewhere within same geologic province or subprovince [3]

II. Possible–Associated with productive formations–less assured,
    1) Similar geologic conditions [4]
    2) Different geologic conditions: e.g., stratigraphic vs. structural trap [5]

III. Speculative–Most nebulous
    1) From nonproductive formation in productive province
        a) new pool [6]
        b) new field [7]
    2) From nonproductive province [8]

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[5] Dolton, G. L. and others, 1981, Estimates of undiscovered recoverable conventional resources of oil and gas in the United States: U.S. Geological Survey Circular 860, 87 p.

[6] U.S. Bureau of Mines, and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, 5 p.

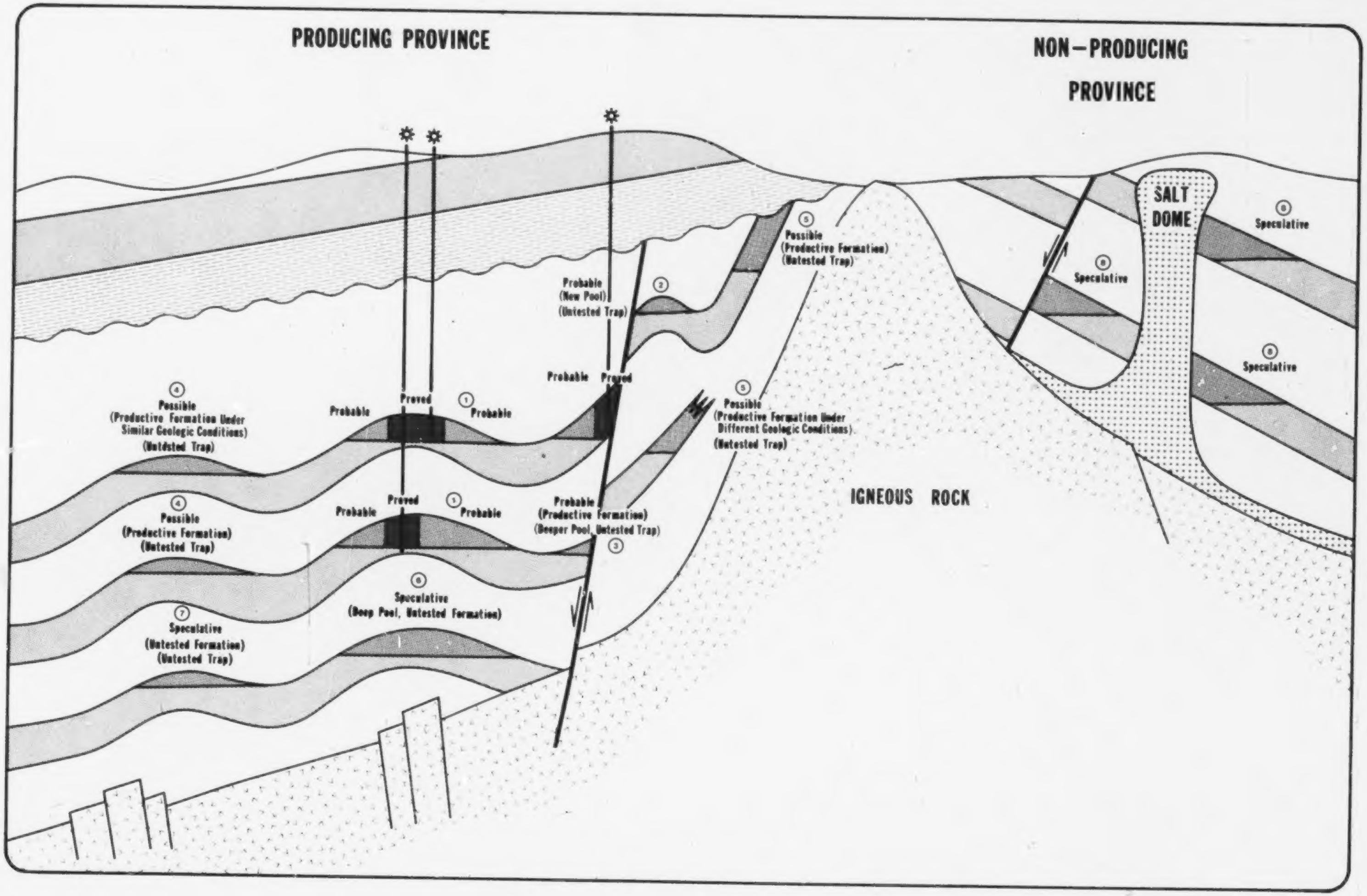
PRODUCING PROVINCE
NON-PRODUCING PROVINCE
SALT DOME
⑧ Speculative
⑧ Speculative
⑧ Speculative
⑤ Possible (Productive Formation) (Untested Trap)
Probable (New Pool) (Untested Trap)
②
Probable
Proved
⑤ Possible (Productive Formation Under Different Geologic Conditions) (Untested Trap)
④ Possible (Productive Formation Under Similar Geologic Conditions) (Untested Trap)
Probable
Proved
① Probable
④ Possible (Productive Formation) (Untested Trap)
Probable
Proved
① Probable
Probable (Productive Formation) (Deeper Pool, Untested Trap)
③
IGNEOUS ROCK
⑥ Speculative (Deep Pool, Untested Formation)
⑦ Speculative (Untested Formation) (Untested Trap)

Figure 2. Schematic representation of categories of potential supply

POTENTIAL GAS COMMITTEE	PROBABLE	POSSIBLE	SPECULATIVE
UNITED STATES GEOLOGICAL SURVEY RESOURCE APPRAISAL GROUP	INFERRED RESERVES	UNDISCOVERED RECOVERABLE RESOURCES	

Figure 3. Comparison of Potential Gas Committee and U.S. Geological Survey natural gas resource classification categories

Estimation of Potential Gas Supply

The following section presents a brief review of the techniques used by the Potential Gas Committee in preparing estimates of the natural gas resources of the United States. More detail concerning the methodology and its application are contained in the procedures manual of the Committee.[1]

The basic technique for estimation of potential gas resources is to compare the factors that control known occurrences of natural gas with factors present in prospective areas. This technique is applied to each of the categories adopted by the Potential Gas Committee. In each case, what is known about the prospective area is evaluated relative to what is known about natural gas accumulations which have been discovered in other parts of the same geologic province or in similar geologic provinces. Natural gas occurrences are related to conditions favoring their formation and accumulation, such as the existence of source rocks, sufficient maturation of organic material, and the presence of reservoir rocks and traps. Studies of producing areas provide information on the productive capacity of particular formations and the average size of accumulations. In its simplest form, the estimate of the potential supply is derived by (1) estimating the volume of potential gas-bearing reservoir rock, (2) multiplying this volume by a yield factor,[2] and (3) discounting to allow for the probability that the traps and/or the accumulations exist. Modifications of the basic technique are necessary to accommodate the variations in amount of information available for prospective areas.

Each estimator considers three separate situations in preparing estimates:

1. Maximum potential resource–The quantity of natural gas which might exist and be recoverable under the most favorable conditions. The probability that such conditions might prevail is assumed to be approximately 10 percent or less, and, thus, only a 10

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[1] Potential Gas Committee, 1984, Definitions and Procedures for Estimation of Potential Gas Resources: Gas Resources Studies Number 2, Potential Gas Agency, Colorado School of Mines, Golden, 16 p.

[2] Yield factors represent the amount of gas expected to be produced from a given unit volume of rock. They are calculated using data from known gas accumulations considered to be most similar to the one being evaluated. The yield is the volume of discovered gas (i.e., cumulative production plus proved reserves) divided by the volume of productive rock containing the discovered gas. The yield factor applied to any prospective area is adjusted to accommodate variations which are appropriate to the prospective area.

percent or less probability exists that at least this much gas resource is present. This assumes the maximum number of potential traps with favorable source bed and reservoir conditions, the maximum reasonable yield factor, and that each trap is filled with recoverable accumulation. Such assumptions would lead to a reasonable estimate of the maximum resource quantity.

2. Minimum potential resource–The existence of the minimum number of traps, the most marginal source beds and reservoir conditions, the minimum reasonable yield factor, and the possibility that many of the traps which might exist would not contain recoverable accumulations of natural gas. In this case, it is assumed that there is approximately a 90 percent or greater probability that at least this much natural gas resource is present. Such assumptions would lead to a reasonable estimate of the minimum resource quantity.

3. Most Likely potential resource–The most reasonable estimate both of the existence of traps and accumulations and the most reasonable assessment of the source bed, yield factor, and reservoir conditions. These conditions would lead to the most likely estimate of the resource quantity.

Estimates of the maximum, most likely and minimum resource potential are given individually for each geologic province. Most likely resource estimates for each province are summed to derive a total resource potential for each Area and for the entire nation. It is believed that the Committee's estimates represent a distribution such that the most likely estimates correspond closely to the statistical mean. Under these conditions the most likely estimates are additive, and the estimates for provinces can be combined to provide estimates for larger areas.

By considering each of the three situations outlined above, the estimator can best express both the limiting conditions within the geologic region and also the most likely estimate of the resource potential. Estimates prepared by the individual estimators are reviewed periodically at meetings of Area Work Committees and by the entire Potential Gas Committee at the national level, in order that a reasonable degree of consistency and uniformity is maintained.

Limiting Considerations

The estimates presented here are limited to the contiguous United States, Alaska, and adjacent offshore areas. Hawaii, the island territories and their adjacent offshore areas are not included.

Potential Gas Committee Work Areas and geologic provinces for the Lower 48 states are shown in Figure 4 and on Plate 1. Alaskan provinces are shown on Plate 2.

Drilling depth and water depth limitations

No potential supply of natural gas is included which exists at subsurface depths greater than 30,000 feet or, in offshore areas, where water depths are in excess of 1,000 meters (3,281 feet). Separate evaluations are made for the potential supply existing at onshore drilling depths from 0 to 15,000 feet and from 15,000 to 30,000 feet. These subdivisions recognize the greater technological and economic difficulties of recovering resources that exist below drilling depths of 15,000 feet. In offshore areas, estimates are made for the potential existing beneath water depths of 0 to 200 meters (656 feet) and 200 to 1,000 meters (3,281 feet). Estimates for water depths less than 200 meters essentially represent the potential supply that may be recovered from beneath the Continental Shelf, whereas the estimates for water depths of 200 to 1,000 meters essentially represent resources that may be recovered from beneath portions of the Continental Slope.

The extension of Potential Gas Committee estimates in 1978 to include offshore areas beneath water depths up to 1,000 meters (3,281 feet) was a significant increase from the previous depth limit of 1,500 feet used in reports from 1968 through 1976. In the opinion of Committee members, there had been sufficient improvement in drilling, production and offshore pipeline technology by 1978 to warrant this extension of limits in keeping with the Committee's concept of including all natural gas resources which could be produced in the future with normal advances in technology. Current research in offshore drilling and production indicates the possibility that production of natural gas resources from beneath water depths greater than

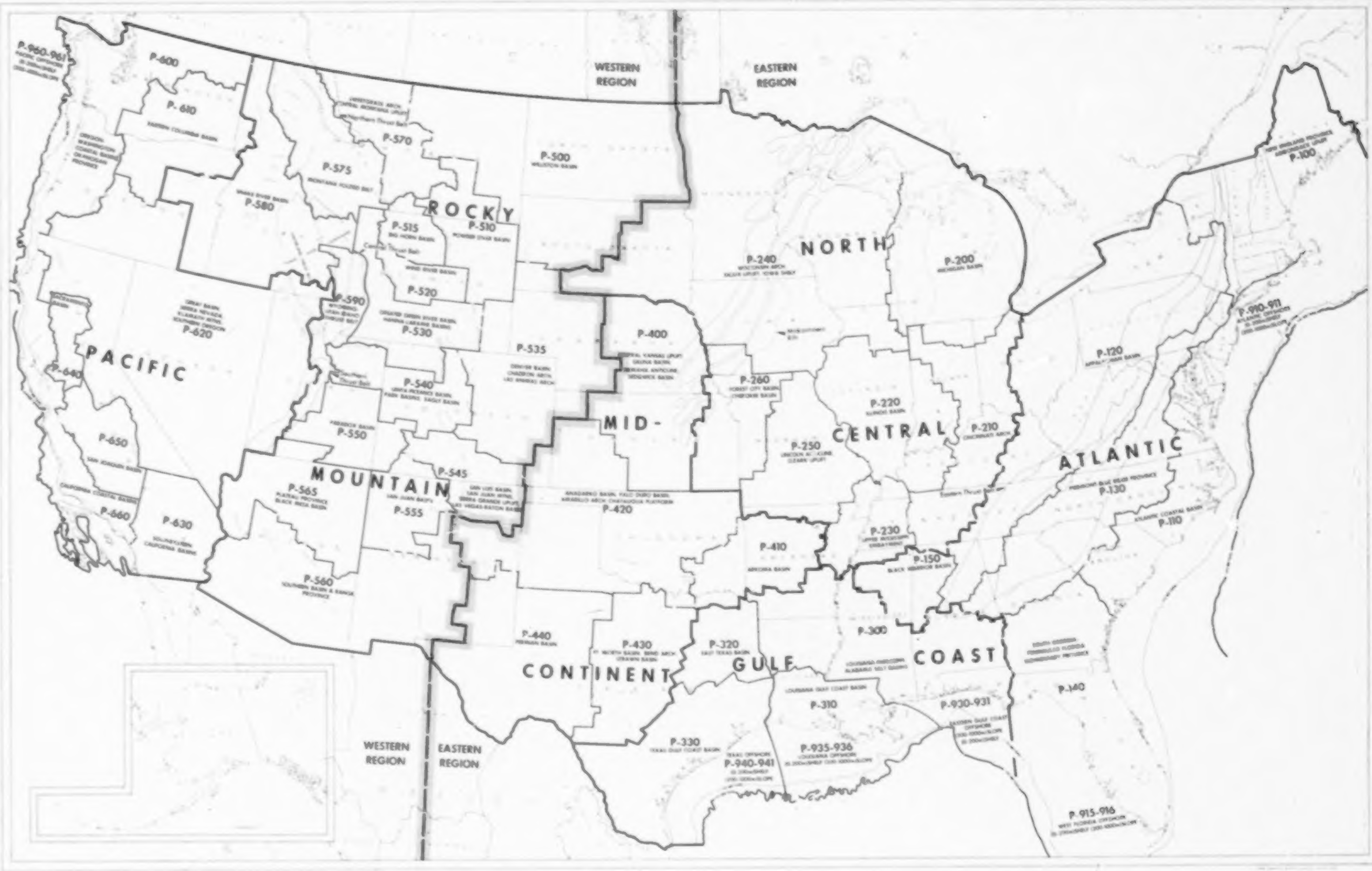
P-960-961
P-600
P-610
Eastern Columbia Basin
P-570
Northern Thrust Belt
P-575
Montana Folded Belt
P-500
Williston Basin
WESTERN REGION
EASTERN REGION
Snake River Basin
P-580
ROCKY
P-515
Big Horn Basin
P-510
Powder River Basin
Central Thrust Belt
Wind River Basin
P-520
P-590
P-530
Greater Green River Basin
P-620
PACIFIC
P-640
P-535
Denver Basin
Chadron Arch
Las Animas Arch
P-540
Southern Thrust Belt
Paradox Basin
P-550
P-650
San Joaquin Basin
California Coastal Basins
P-660
P-630
MOUNTAIN
P-565
Plateau Province
Black Mesa Basin
P-545
San Juan Basin
P-555
P-560
Southern Basin & Range Province
P-400
MID-
P-420
P-440
Permian Basin
P-430
CONTINENT
P-240
NORTH
P-200
Michigan Basin
P-260
Forest City Basin
Cherokee Basin
P-250
P-220
Illinois Basin
CENTRAL
P-210
Cincinnati Arch
P-410
Arkoma Basin
P-230
P-150
Black Warrior Basin
Eastern Thrust Belt
P-100
P-910-911
P-120
Appalachian Basin
ATLANTIC
Piedmont Blue Ridge Province
P-130
Atlantic Coastal Basin
P-110
P-320
East Texas Basin
GULF
P-300
COAST
Louisiana Gulf Coast Basin
P-310
P-330
Texas Gulf Coast Basin
P-940-941
P-935-936
P-930-931
P-140
P-915-916
WESTERN REGION
EASTERN REGION

Figure 4. Potential Gas Committee work areas and geologic provinces

1,000 meters may be feasible in the later years of this century or in the early years of the 21st century. No estimate of the resources which may occur beneath these deep waters is included in this report. The Potential Gas Committee is studying the feasibility of including, in future reports, estimates for resources beneath water depths of 1,000 to 2,500 meters.

Estimates made by the Area Work Committees include resources which exist beneath areas presently withdrawn or proposed for withdrawal from exploration and development because of governmental action. Where considerable potential exists beneath these withdrawn areas, it is appropriate that estimates of this potential be made and presented in the narrative portion of the report submitted by each Area Committee.

Economic, technological and policy considerations

Economic, technological and governmental policy considerations taken into account in the Potential Gas Committee's estimate of potential gas supply are related to (l) past production and proved reserves of natural gas, and (2) all wells which would be drilled in the future under the assumed conditions of adequate economic incentives in terms of price/cost relationships and current or foreseeable technology. Fundamental economic considerations--which include but are not limited to prices, costs, rates of take, recovery factors, abandonment pressures, etc.--are inherent in the definition of proved reserves:

> ". . . recoverable in the future from known oil and gas reservoirs under existing economic and operating conditions."

Some gas that is actually present in known reservoirs is not producible because of an unfavorable price/cost relationship and, therefore, is not included in recoverable reserves. Furthermore, there are other known gas accumulations of such small size that none of the gas can be produced in commercial quantities under ". . . existing economic and operating conditions." Such considerations result in proved reserves being somewhat less than the total volumes of gas existing in known reservoirs. These same limitations are applicable to the estimates of potential supply. If a fundamental change in economics or technology occurs, estimates of potential supply will be changed accordingly.

The attribution technique presented in the Estimation of Potential Gas Supply section describes relationships between ultimately recoverable volumes of gas from known occurrences and prospective gas accumulations, after appropriate adjustment for variations in geological and reservoir conditions. The explicit assumptions of adequate but reasonable prices and normal improvements in technology in the definition of potential supply relate to improvements in exploration and production techniques. Adequate prices, normal technological improvements and reasonable governmental policies are required to bring about the drilling necessary to prove the potential supply. These assumed conditions permit estimates of potential supply to be made by the Potential Gas Committee on the basis of relevant past history and experience concerning recovery factors, as well as the size and type of reservoirs which have been found, developed, and produced, without speculating as to future levels of prices and costs.

Unconventional resources

This report does not include any potential supply of natural gas which might be recoverable from geopressured-geothermal brines of the U.S. Gulf Coast regions, directly from gaseous coal seams, or from gas hydrates. However, where coals may have served as source beds for gas accumulations in conventional sandstone or limestone reservoirs, the potential resource contained in the conventional reservoir and recoverable by conventional drilling and production is included in the Committee's estimates. The potential resource from certain black (Devonian) shales is largely excluded except that potential which the Committee believes to be recoverable by normal drilling and well stimulation and completion techniques and which is analogous in geologic setting to previous production. The natural gas potential from tight (low permeability) formations (including sandstone, shale and carbonate reservoirs) is included in the Committee's estimates to the extent that these resources fall within the limiting considerations for resource estimation.

The inclusion of resources from tight formations raises questions concerning the relationship of the estimates of the Committee to the estimates prepared by others for the resources in tight formations. Many estimates dealing with natural gas resources contained in "tight" formations have not included a clear definition of the upper limits of permeability of such formations. Some of the more recent estimates have included resources in formations with *in situ* effective permeabilities of up to 1 millidarcy.[3] In the preparation of year-end 1982 and 1984 estimates, the Potential Gas Committee considered the question of the magnitude of the resources included in the Committee's estimates which might lie in formations which have *in situ* effective permeabilities to natural gas of less than 0.1 millidarcy. Such resources may occur in reservoir rocks of any lithology including sandstones, shales and carbonate rocks.

Figure 5 illustrates diagrammatically the overlap of resource estimates prepared by the Potential Gas Committee with the estimates prepared by others who have investigated the unconventional resource potential which may exist in formations with low permeability. Previous studies have concentrated largely on Western "tight gas sands" and Eastern Devonian shales. Estimates of the Potential Gas Committee extend from "conventional" resources to the limits of technology and economics used as limiting considerations by the Committee. A portion of the resources estimated by the Potential Gas Committee in all categories is contained in formations which have *in situ* permeabilities to natural gas of less than 0.1 millidarcy. These quantities have been incorporated gradually, over a number of years, into the Committee's estimates as changing technology and economics have transformed former "unconventional" resources into "conventional" resources.

In recent years, increasing amounts of natural gas have been produced directly from coal seams by wells completed in those seams. This resource is significant in several sedimentary basins, including the Black Warrior basin of Alabama and Mississippi, portions of the Appalachian basin, the San Juan basin of New Mexico and Colorado and the Piceance basin of Colorado. Members of the Potential Gas Committee are studying this resource and its potential magnitude, but estimates of the resource potential are not included in this current report, due largely to lack of information concerning reservoir characteristics and production capabilities of wells. It is intended to address this question in future reports.

A review of nonconventional natural gas resources was prepared by the Potential Gas Agency and presented in Part II of the Potential Gas Committee report for 1980.[4] This review was not an independent appraisal by either the Potential Gas Committee or Potential Gas Agency of the volume of natural gas within nonconventional sources. Its purpose was to provide current information concerning research on nonconventional sources of natural gas and to present published estimates of the potential from such sources. The reader is referred to this report for further information.

National Summary Statistics

The following tables summarize the Potential Gas Committee resource estimates on a national basis. Additionally, data have been derived from the Committee on Natural Gas Reserves of the American Gas Association,[5] and the Energy Information Administration.[6]

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[3] National Petroleum Council, 1980, Unconventional Gas Sources–Volume V–Tight Gas Reservoirs.

[4] Potential Gas Committee, 1981, Potential Supply of Natural Gas in the United States (as of December 31, 1980): Potential Gas Agency, Colorado School of Mines, Golden, 119 p.

[5] American Gas Association, 1980, Report of the Committee on Natural Gas Reserves, in American Petroleum Institute, American Gas Association, and Canadian Petroleum Association, Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada as of December 31, 1979 (and earlier years): Washington, D.C.

[6] Energy Information Administration, 1984, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 1983 Annual Report (and earlier years): U.S. Department of Energy, Energy Information Administration, Washington, D.C., Publication DOE/EIS-0216(83).

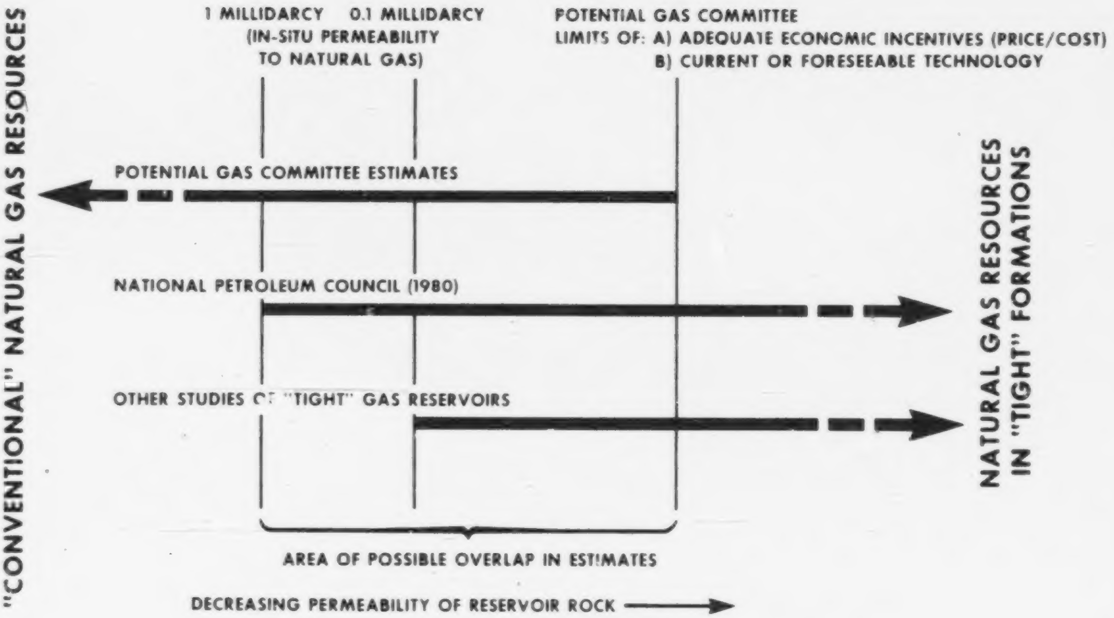
"CONVENTIONAL" NATURAL GAS RESOURCES
1 MILLIDARCY
0.1 MILLIDARCY
(IN-SITU PERMEABILITY
TO NATURAL GAS)
POTENTIAL GAS COMMITTEE
LIMITS OF: A) ADEQUATE ECONOMIC INCENTIVES (PRICE/COST)
B) CURRENT OR FORESEEABLE TECHNOLOGY
POTENTIAL GAS COMMITTEE ESTIMATES
NATIONAL PETROLEUM COUNCIL (1980)
OTHER STUDIES OF "TIGHT" GAS RESERVOIRS
NATURAL GAS RESOURCES IN "TIGHT" FORMATIONS
AREA OF POSSIBLE OVERLAP IN ESTIMATES
DECREASING PERMEABILITY OF RESERVOIR ROCK

Figure 5. Schematic representation of the relationship between Potential Gas Committee resource estimates and estimates of natural gas resources in low permeability formations

Table 2. Potential Gas Committee 1984 Estimates by Area.
(Most Likely Values--Billion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Atlantic			
Onshore			
0-15,000'	24,290	8,400	24,520
15-30,000'	*	400	11,100
TOTAL	24,290	8,800	35,620
Offshore			
0-200 m	**	**	14,790
200-1,000 m	**	**	660
TOTAL	**	**	15,450
AREA TOTAL	24,290	8,800	51,070
North Central			
Onshore			
0-15,000'	72	2,250	10,310
15-30,000'	**	**	*
AREA TOTAL	72	2,250	10,310
Gulf Coast			
Onshore			
0-15,000'	12,965	18,020	6,500
15-30,000'	9,805	22,090	11,950
TOTAL	22,770	40,110	18,450
Offshore			
0-200 m	29,100	36,000	8,500
200-1,000 m	2,900	19,900	11,250
TOTAL	32,000	55,900	19,750
AREA TOTAL	54,770	96,010	38,200
Mid-Continent			
Onshore			
0-15,000'	30,260	38,470	26,360
15-30,000'	16,000	49,700	32,000
AREA TOTAL	46,260	88,170	58,360

*Negligible quantity estimated.
**Production has not been established; no Probable or Possible resource exists.

Table 2 (continued). Potential Gas Committee 1984 Estimates by Area.
(Most Likely Values--Billion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Rocky Mountain			
Onshore			
0-15,000'	30,945	28,546	18,300
15-30,000'	17,400	24,450	15,100
AREA TOTAL	48,345	52,996	33,400
Pacific			
Onshore			
0-15,000'	1,465	5,550	6,000
15-30,000'	200	1,150	900
TOTAL	1,665	6,700	6,900
Offshore			
0-200 m	74	4,735	3,661
200-1,000 m	182	4,178	5,167
TOTAL	256	8,913	8,828
AREA TOTAL	1,921	15,613	15,728
TOTAL LOWER 48 STATES	175,658	263,839	207,068
Alaska			
Onshore			
0-15,000'	6,700	16,400	27,690
15-30,000'	**	**	*
TOTAL	6,700	16,400	27,690
Offshore			
0-200 m	2,400	12,700	66,630
200-1,000 m	**	**	4,840
TOTAL	2,400	12,700	71,470
AREA TOTAL	9,100	29,100	99,160
TOTAL UNITED STATES	184,758	292,939	306,228

*Negligible quantity estimated.
**Production has not been established; no Probable or Possible resource exists.

Table 3. Potential Gas Committee 1984 Estimates--total United States
(Most Likely Values--billion cubic feet)

	PROBABLE	POSSIBLE	SPECULATIVE
ONSHORE (drilling depth)			
Lower 48 states			
less than 15,000 feet	99,997	101,236	91,990
15,000 to 30,000 feet	43,405	97,790	71,050
Alaska			
less than 15,000 feet	6,700	16,400	27,690
15,000 to 30,000 feet	**	**	*
TOTAL ONSHORE	150,102	215,426	190,730
OFFSHORE (water depth)			
Lower 48 states			
less than 200 meters	29,174	40,735	26,951
200 to 1,000 meters	3,082	24,078	17,077
Alaska			
less than 200 meters	2,400	12,700	66,630
200 to 1,000 meters	**	**	4,840
TOTAL OFFSHORE	34,656	77,513	115,498
TOTAL LOWER 48 STATES	175,658	263,839	207,068
TOTAL ALASKA	9,100	29,100	99,160
TOTAL UNITED STATES	184,758	292,939	306,228

*Negligible quantity estimated.

**Production has not been established; no Probable or Possible resource exists.

Table 4. Estimated potential supply of natural gas, December 31, 1984.
Onshore, 0-15,000'
(Most Likely Values--billion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Atlantic	24,290	8,400	24,520
North Central	72	2,250	10,310
Gulf Coast	12,965	18,020	6,500
Mid-Continent	30,260	38,470	26,360
Rocky Mountain	30,945	28,546	18,300
Pacific	1,465	5,550	6,000
TOTAL LOWER 48 STATES	99,997	101,236	91,990
Alaska	6,700	16,400	27,690
TOTAL UNITED STATES	106,697	117,636	119,680

Table 5. Estimated potential supply of natural gas, December 31, 1984.
Onshore, 15,000-30,000'
(Most Likely Values--billion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Atlantic	*	400	11,100
North Central	**	**	*
Gulf Coast	9,805	22,090	11,950
Mid-Continent	16,000	49,700	32,000
Rocky Mountain	17,400	24,450	15,100
Pacific	200	1,150	900
TOTAL LOWER 48 STATES	43,405	97,790	71,050
Alaska	**	**	*
TOTAL UNITED STATES	43,405	97,790	71,050

*Negligible quantity estimated.
**Production has not been established; no Probable or Possible resource exists.

Table 6. Estimated potential supply of natural gas, December 31, 1984.
Offshore, 0-200m
(Most Likely Values--billion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Atlantic	**	**	14,790
Gulf Coast	29,100	36,000	8,500
Pacific	74	4,735	3,661
TOTAL LOWER 48 STATES	29,174	40,735	26,951
Alaska	2,400	12,700	66,630
TOTAL UNITED STATES	31,574	53,435	93,581

**Production has not been established; no Probable or Possible resource exists.

Table 7. Estimated potential supply of natural gas, December 31, 1984.
Offshore, 200-1,000m
(Most Likely Values--billion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Atlantic	**	**	660
Gulf Coast	2,900	19,900	11,250
Pacific	182	4,178	5,167
TOTAL LOWER 48 STATES	3,082	24,078	17,077
Alaska	**	**	4,840
TOTAL UNITED STATES	3,082	24,078	21,917

**Production has not been established; no Probable or Possible resource exists.

Table 8. Comparison of estimates of ultimately recoverable volumes of natural gas in the United States for period December 31, 1966 to December 31, 1984 (trillion cubic feet).

Year	Annual Production[1]	Cumulative Production[2]	Proved Reserves[3]	Potential Supply[4]	Ultimately Recoverable Resource
1964	15	273	281	630 *	1184 *
1966	17	307	289	690 *	1286 *
1968	19	345	287	1227	1859
1970	22	387	291	1178	1856
1972	23	432	266	1146	1844
1974	21	477	237	1146	1860
1976	20	515	216	948	1679
1978	19	553	200	1019	1772
1980	19	596	199	913	1708
1982	18	632	202	876	1710
1984	17	665	200 est.	784	1649

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[1] Annual production figures from AGA Committee on Natural Gas Reserves and U.S. Department of Energy, Energy Information Administration.

[2] Cumulative production figures derived from AGA Committee on Natural Gas Reserves, plus annual production from U.S. Department of Energy, Energy Information Administration.

[3] Proved reserves derived from reports of the AGA Committee on Natural Gas Reserves for years through 1979. Proved reserves for years from 1980 on are derived from reports of U.S. Department of Energy, Energy Information Administration. Proved reserves shown for 1984 are an estimate only.

[4] Potential supply from estimates of Potential Gas Committee.

*Lower 48 states only

Table 9. Comparison of estimates of potential supply of natural gas from Potential Gas Committee reports
(Most Likely Values--trillion cubic feet)

	PROBABLE	POSSIBLE	SPECULATIVE	TOTAL
LOWER 48 STATES				
As of 12-31-66	300	210	180	690
As of 12-31-68	238	317	245	800
As of 12-31-70	218	326	307	851
As of 12-31-72	212	290	278	780
As of 12-31-76	192	318	188 to 238	698 to 748
As of 12-31-78	186	359	285	830
As of 12-31-80	185	329	254	768
As of 12-31-82	184	326	232	742
As of 12-31-84	176	264	207	647
TOTAL UNITED STATES				
As of 12-31-68	260	335	632	1,227
As of 12-31-70	257	387	534	1,178
As of 12-31-72	266	384	496	1,146
As of 12-31-76	215	363	345 to 395	923 to 973
As of 12-31-78	199	399	421	1,019
As of 12-31-80	193	358	362	913
As of 12-31-82	192	355	329	876
As of 12-31-84	185	293	306	784

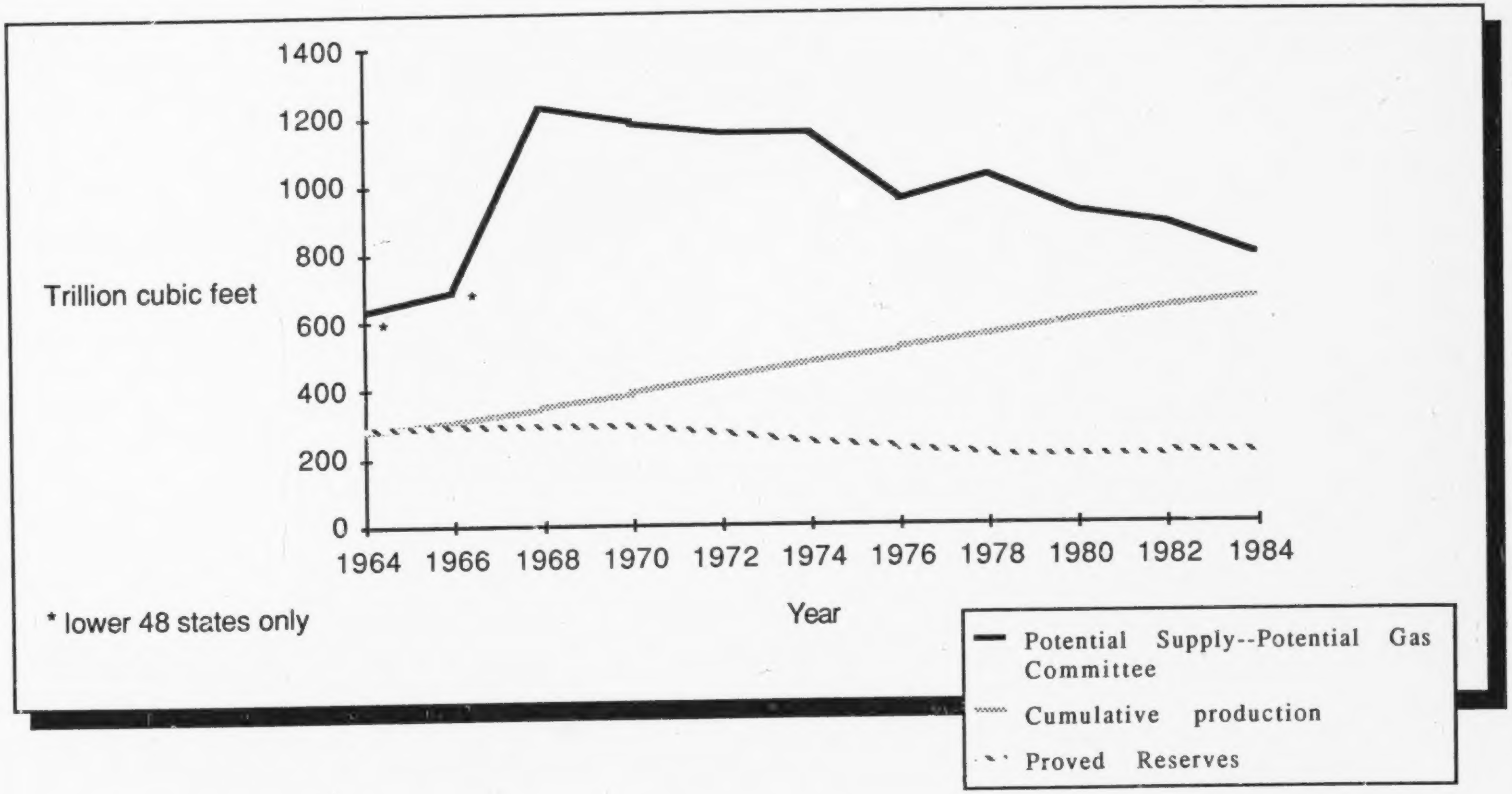

Figure 6. Cumulative production, proved reserves and potential supply of natural gas in the United States.

Table 10. Comparison of estimates, 1982* and 1984, by Area
(Most Likely Values--trillion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Atlantic			
1982			
Onshore	27	10	33
Offshore	0	0	14
TOTAL	27	10	47
1984			
Onshore	24	9	36
Offshore	0	0	15
TOTAL	24	9	51
North Central			
1982			
TOTAL	0	2	8
1984			
TOTAL	0	2	10
Gulf Coast			
1982			
Onshore	25	39	13
Offshore	33	70	24
TOTAL	58	109	37
1984			
Onshore	23	40	18
Offshore	32	56	20
TOTAL	55	96	38
Mid-Continent			
1982			
TOTAL	46	92	56
1984			
TOTAL	46	88	58
Rocky Mountain			
1982			
TOTAL	51	96	67
1984			
TOTAL	48	53	33
Pacific			
1982			
Onshore	2	8	8
Offshore	--	9	9
TOTAL	2	17	17
1984			
Onshore	2	7	7
Offshore	0	9	9
TOTAL	2	16	16
TOTAL LOWER 48 STATES			
1982	184	326	232
1984	175	264	206

Table 10 (continued). Comparison of estimates, 1982* and 1984, by Area
(Most Likely Values--trillion cubic feet)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
Alaska			
1982			
Onshore	6	16	28
Offshore	2	13	69
TOTAL	8	29	97
1984			
Onshore	7	16	28
Offshore	2	13	71
TOTAL	9	29	99
TOTAL UNITED STATES			
1982	192	355	329
1984	185**	293	306**

* Data for 1982 have been adjusted to 1984 Potential Gas Committee Areas.
**Individual Area estimates do not add to total because of rounding.

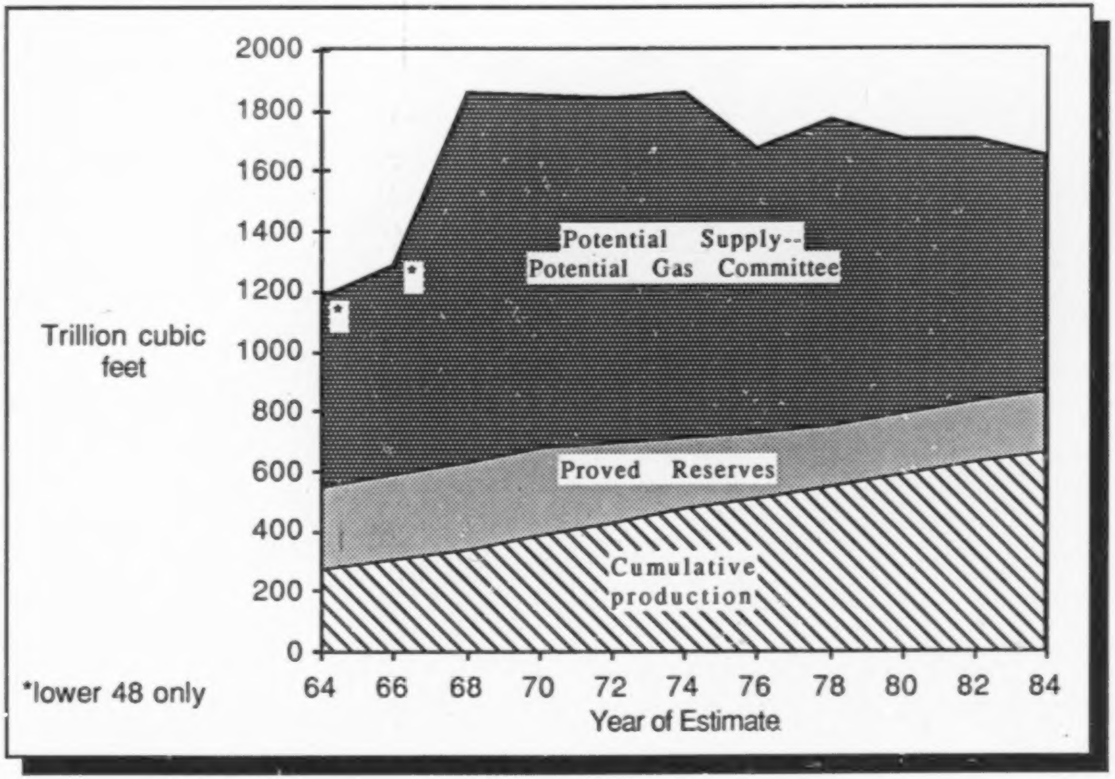

Figure 7. Estimates of ultimately recoverable resource of natural gas in the United States

POTENTIAL GAS COMMITTEE

NATURAL GAS RESOURCE ESTIMATES

(December 31, 1984)

The following pages comprise the Potential Gas Committee's estimate of potential natural gas resources for the United States as of December 31, 1984. The estimates are presented by Work Area and by geologic province within each Work Area.

A summary of the geology and natural gas resource potential for each geologic province is presented in order to provide the reader with brief background information about the province. This summary is not intended to be an exhaustive treatment, but rather to cover the fundamental geologic setting and its significance relative to natural gas occurrence. Information has been derived from a number of sources, especially Landes[1] and Cram.[2] Additional information has been provided in personal communication from members of the Potential Gas Committee.

Generalized stratigraphic sections have been provided for a number of the geologic provinces, especially those with significant natural gas potential. These stratigraphic sections are not necessarily accurate in all details, but they should serve to orient the reader concerning the stratigraphic position and age of reservoir and source rocks mentioned in the text. In addition to the sources listed for the geologic summaries, information for the stratigraphic sections has been derived from the published stratigraphic sections of the COSUNA project.[3] Other charts in the COSUNA series are still in press and were not utilized.

Where data are available, a brief listing of selected gas fields is given for the provinces. This does not represent, by any means, a complete listing of the gas-producing fields within the province, but rather includes some of the larger fields in order to present the reader with a picture of the original reserves and current remaining reserves in such fields within the province. Data for these tables have been derived largely from work of the American Gas Association Committee on Natural Gas Reserves.[4] Additional information on cumulative production has been provided by members of the Potential Gas Committee and other industry and state sources. Production and reserves data are for December 31, 1984 unless otherwise indicated.

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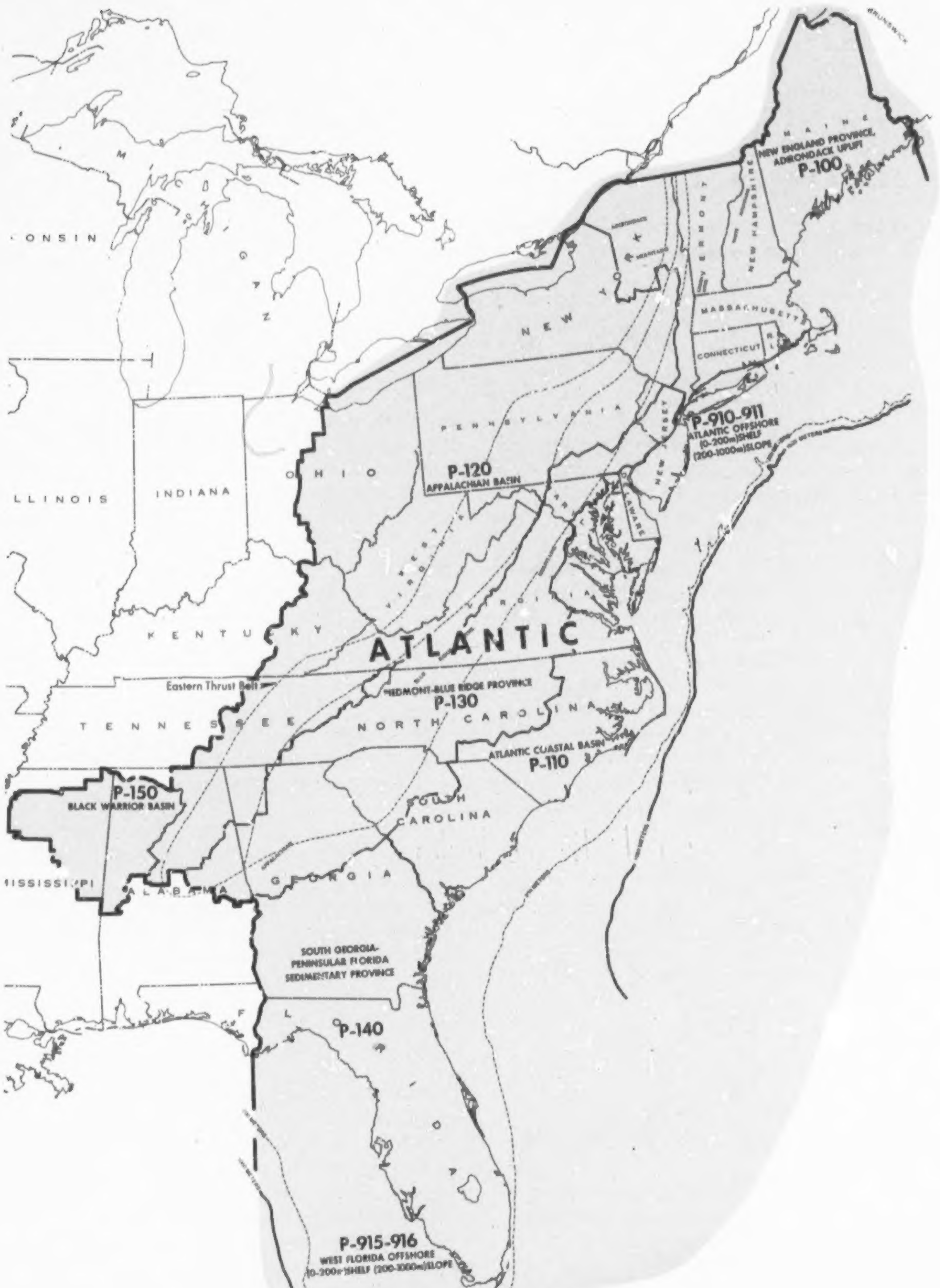
[1] Landes, K. K., 1970, Petroleum Geology of the United States: Wiley-Interscience, New York, 571 p.

[2] Cram, I. H., ed., 1971, Future Petroleum Provinces of the United States–Their Geology and Potential: American Association of Petroleum Geologists, Memoir 15, Tulsa, 1,496 p.

[3] Correlation of Stratigraphic Units of North America (COSUNA) Project: American Association of Petroleum Geologists, Tulsa.

[4] American Gas Association, 1985, Report on Selected Fields by the Committee on Natural Gas Reserves of the American Gas Association, December 31, 1984: American Gas Association, Arlington, VA.


BRUNSWICK
MAINE
NEW ENGLAND PROVINCE, ADIRONDACK UPLIFT
P-100
VERMONT
NEW HAMPSHIRE
CONSIN
MICHIGAN
NEW YORK
MASSACHUSETTS
CONNECTICUT
R. I.
PENNSYLVANIA
P-910-911
ATLANTIC OFFSHORE
(0-200m)SHELF
(200-1000m)SLOPE
NEW JERSEY
DELAWARE
P-120
APPALACHIAN BASIN
OHIO
ILLINOIS
INDIANA
WEST VIRGINIA
MARYLAND
VIRGINIA
KENTUCKY
ATLANTIC
Eastern Thrust Belt
PIEDMONT-BLUE RIDGE PROVINCE
P-130
TENNESSEE
NORTH CAROLINA
ATLANTIC COASTAL BASIN
P-110
P-150
BLACK WARRIOR BASIN
SOUTH CAROLINA
MISSISSIPPI
ALABAMA
GEORGIA
SOUTH GEORGIA-PENINSULAR FLORIDA SEDIMENTARY PROVINCE
FLORIDA
P-140
P-915-916
WEST FLORIDA OFFSHORE
(0-200m)SHELF (200-1000m)SLOPE

ATLANTIC AREA

The only geologic provinces of the Atlantic Area which are currently productive of natural gas are the Appalachian basin and the Black Warrior basin. Other provinces which have potential for future resource development are the New England and Adirondack uplift province, the Atlantic Coastal basin, the Piedmont-Blue Ridge province, the South Georgia-Peninsular Florida sedimentary province, and the Atlantic and West Florida Offshore provinces.

P-100, NEW ENGLAND PROVINCE AND ADIRONDACK UPLIFT

This province includes the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, Vermont and 14 counties in eastern New York State. No production of oil or natural gas has been established in this area. Sedimentary rocks in the area are predominantly of Paleozoic age, reaching a thickness of 15,000 to 20,000 feet. Additionally, there is a thick sequence of sedimentary rocks of Triassic age in the Connecticut Triassic basin. All postulated natural gas potential is located in the Connecticut Triassic basin and in the Eastern Thrust Belt which extends into eastern New York and western Vermont. Potential reservoir rocks in the Eastern Thrust Belt are of Ordovician and Cambrian age and occur both in the area of surface exposure of Paleozoic rocks (west) and the area in which the Paleozoic rocks are concealed beneath thrusted older rocks (east).

P-110, ATLANTIC COASTAL BASIN

This province includes the entire state of Delaware and portions of New Jersey, Maryland, Virginia, North Carolina and South Carolina. No production of oil or gas has been established to date. The province is bordered generally on the west by the Appalachian and Blue Ridge Mountains and includes an area of over 108,000 square miles. Sedimentary rocks range in age from Triassic(?) or Jurassic to Quaternary. Recent geophysical surveys and deep drilling have established that there are greater thicknesses of sedimentary rocks in this province than previously thought, greatly in excess of previous estimates of 10,000 feet. Potential for natural gas is believed to be limited largely to the Triassic basins, both those in which Triassic rocks are exposed at the surface and those in which younger sedimentary rocks cover the Triassic. There is also some potential in the deeper formations in the coastal areas of North and South Carolina.

P-120, APPALACHIAN BASIN

The Appalachian basin province covers an area of over 180,000 square miles in portions of the states of New York, Pennsylvania, New Jersey, West Virginia, Virginia, Maryland, Ohio, Kentucky, Tennessee, Georgia and Alabama. Its eastern border includes the Appalachian Mountains and it extends westward to the Cincinnati arch and the Nashville dome. Sedimentary rocks in the basin exceed thicknesses of 30,000 feet in places, and potential reservoir rocks range in age from Cambrian to Pennsylvanian.

Although several hundred thousand wells have been drilled in the Appalachian basin, most of them have been relatively shallow (less than 5,000 feet) and concentrated along narrow producing trends. In the entire basin, only eleven wells have been drilled to a depth deeper than 15,000 feet. Only 10-15% of the possible hydrocarbon-producing sediments have been tested and, in terms of exploration, the basin is relatively young.

The gas included in the Probable category will be found mostly in field extensions, infill drilling and connecting old fields. The gas classified as Possible is expected to be found in fields ranging in size from 5-500 Bcf with most of them being in the 15-50 Bcf range. The gas classified Speculative will be found in fields ranging in size from 50-1,000 Bcf with the most likely size being between 300-500 Bcf.

Reservoir rocks. Both detrital rocks and carbonates form potential reservoirs, and production has already been established from most potential reservoirs in at least some part of the basin. Production

P-110, ATLANTIC COASTAL BASIN
Generalized Stratigraphic Section

AGE	FORMATION		GENERAL LITHOLOGY
	North	South	
Cenozoic			
Quaternary	Holocene-Pleistocene deposits		sandstone and shale
Tertiary			
Pliocene	Yorktown Formation		sandstone and shale
Miocene	St. Marys Fm.-Choptank Fm.-Calvert Fm.-Hawthorn Fm.		sandstone and shale
		Pungo R. Fm.	
Oligocene	River Bend Fm. - Cooper Fm.		limestone, sandstone
Eocene	Nanjemoy Fm.- Pamunkey Grp.- Castle Hayne Fm.-		sandstone, shale,
		Santee Ls. -Huber Fm.	limestone
		Black Mingo Fm.	sandstone, siltstone, shale
Paleocene	Aquia Fm.	Beaufort Fm.	sandstone and shale
Mesozoic			
Late Cretaceous	unit "A"	Peedee Fm.	shale and sandstone
	unit "B"	Black Creek Fm.	sandstone, siltstone, shale
	unit "C"		
	unit "D"	Middendorf Fm.	shale and sandstone
	unit "E"	Cape Fear Fm.	shale, siltstone, sandstone, limestone
	unit "F"		shale and sandstone
Early Cretaceous	unit "G"		shale and sandstone
	unit "H"		shale and sandstone
Jurassic (?)			red beds and basalts
Triassic (?)	Newark Grp.	unnamed red beds	red beds, sandstone, shale, siltstone
Pre-Mesozoic basement			

from Mississippian-Pennsylvanian, Devonian, Silurian, middle Late Ordovician and Cambro-Ordovician units is located, generally, along long, regional anticlinal trends that are oriented in a northeast-southwest direction. Fracturing plays an important role in the deeper reservoirs.

Traps. Stratigraphic, structural and combination traps are all abundant. Lenses, reefs and porosity variations are most important in Silurian and Mississippian reservoirs. Truncations are characteristic of Silurian-Ordovician strata. Production from widespread Devonian shales is closely related to regional fracturing patterns. Shales also form traps and seals for contained sandstone lenses. Anticlines and faulted anticlines form major traps for hydrocarbons in Devonian and Carboniferous reservoirs.

Potential source rocks. Probable source rocks for both oil and gas range from the thermally moderately mature to severely altered mid-Cambrian Rome Shale gas generators to the mid- to late Mississippian Big Lime Formation which is a thermally moderately mature to immature source for both oil and gas. Surface seeps, tar sands and solid hydrocarbon exposures are all known from the province.

Producing trends. The central portion of the basin is basically one giant gas field, extending more than 500 miles along a northeast-southwest trend and 50 to 75 miles wide. A similar trend farther to the west parallels the giant field; here, gas production is generally more scattered in thousands of fields. This western trend defines the limit of the Appalachian basin in the west. The vast majority of the counties included within the limits of the Appalachian basin have at least some gas production. The Cambro-Ordovician Rome Formation is productive of both gas and oil at depths of almost 15,000 feet, whereas the Mississippian Berea sandstones and siltstones produce from the surface to depths of 6,100 feet.

P-120, APPALACHIAN BASIN
Cumulative Production and Remaining Proved Reserves

Cumulative natural gas production and remaining proved reserves from the states of the Appalachian basin are listed below. These figures include areas of the states which fall outside of the boundaries of the Appalachian basin province as well as areas within the province. Reserves data were obtained from the American Gas Association Committee on Natural Gas Reserves. Production data were obtained from the publications of the Committee on Natural Gas Reserves and the Department of Energy, Energy Information Administration, plus state and industry sources.

State	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Kentucky	3,681,920	607,783
Maryland	47,891	573
New York	682,548	317,220
Ohio	6,308,699	1,405,681
Pennsylvania	9,851,144	1,880,735
Tennessee	66,202	72,089
Virginia	N/A	109,362
West Virginia	15,947,408	2,532,540

P-120, APPALACHIAN BASIN
Generalized Stratigraphic Section

AGE	FORMATION		GENERAL LITHOLOGY
	North	South	
Paleozoic			
Permian	Dunkard Formation		shales, red beds
Pennsylvanian	Monongahela Formation		shale
	Conemaugh Formation		sandstone and shale
	Allegheny Formation		sandstone and shale
	Pottsville Sandstone		sandstone
Mississippian	Mauch Chunk Formation		sandstone and shale
	Greenbrier Limestone ("Big Lime")		limestone
	Pocono Group		
	Keener Sandstone		sandstone
	Big Injun Sandstone		sandstone
	Squaw Sandstone		sandstone
	Weir Sandstone		sandstone
	Berea Sandstone		sandstone
Devonian	Catskill Fm. and Chemung Fm.		sandstone and shale
	Conewango Grp.		
	Conneaut Grp.	Bradford sands	
	Canadaway Grp.		
	Benson Sand		sandstone
	Devonian shales		shale
	Onondaga Limestone	Huntersville Chert	limestone, chert
	Oriskany Sandstone		sandstone
	Helderberg Group		limestone
Silurian	Salina Fm.	Cayugan Dolomite	dolomite and evaporites
	Lockport-Guelph Fm.	Newburg Sandstone	limestone, dolo., sandstone
		Big Six Sandstone	sandstone
		Keefer Sandstone	sandstone
	Tuscarora Sandstone	"Clinton" Fm.	sandstone and shale
	Medina sandstones		sandstone
Ordovician	Oswego Ss.	upper Ordovician shale	sandstone, shale
	Trenton-Black River Formation		limestone
	Beekmantown Dolomite	Knox Dolomite	dolomite
Cambrian/Ordovician	Gatesburg Ss. Potsdam Ss.	"St. Peter" Ss.	sandstone
	Roserun Ss. Rome Ss.	Weverton Ss.	
Precambrian			

P-130, PIEDMONT—BLUE RIDGE PROVINCE

This province covers portions of the states of Alabama, Georgia, South Carolina, North Carolina, Tennessee, Virginia, Maryland, Delaware, Pennsylvania and New Jersey, and includes an area of approximately 94,000 square miles. The province lies within the Appalachian and Blue Ridge Mountain regions and the Eastern, or Blue Ridge, Overthrust Belt is the major tectonic feature. Sedimentary rocks within the province are in excess of 30,000 feet thick and range in age from Precambrian upward, but are mainly of early Paleozoic age. No oil or natural gas production has been established in this province to date.

Reservoir rocks. Potential reservoir rocks are of Cambrian through Mississippian age. They are concealed by metamorphic rocks and granites which have been thrust from the east westward across the younger sedimentary rocks. Suspected important reservoir formations include the Cambro-Ordovician Knox Dolomite, the early Cambrian Rome Formation (shale, sandstone and dolomite) and the Precambrian to Cambrian Chilhowee Group (fractured shales).

Traps. Major anticlines within the concealed sedimentary section are interpreted from seismic cross sections and are anticipated to be the principal trapping mechanism.

Potential source rocks. The mid-Ordovician and mid-Cambrian shales are postulated to be potential source rocks for natural gas and are thermally mature. Gas shows have been reported from similar rocks to the west.

P-140, SOUTH GEORGIA—PENINSULAR FLORIDA SEDIMENTARY PROVINCE

This province covers the southern half of Georgia and most of the State of Florida with the exception of the Florida Panhandle. It is bordered on the north by the Appalachian Mountain System. The major tectonic elements include the Southeast Georgia Embayment, the northeastern portion of the Appalachicola basin, and the South Florida basin. Sedimentary rocks reach a maximum thickness of 15,000 feet. Production of oil and associated/dissolved natural gas has been established in southern Florida, but the major natural gas production in Florida is located outside of this province in the Florida Panhandle (Province P-300).

Reservoir rocks. Sedimentary rocks in the province range in age from Early Cretaceous to Tertiary and include limestones, dolomites and sandstones. Reservoir rocks for oil and associated/dissolved gas are principally Early Cretaceous limestones at depths of up to 9,000 feet.

Traps. Changes in porosity and permeability within the carbonate reservoir rocks, possibly associated with folds, are the principal trapping mechanisms.

Potential source rocks. Potential source rocks for gas and oil include the thermally immature Cedar Keys Formation (Paleocene) and the moderately mature Sunniland Limestone (Early Cretaceous).

P-140, SOUTH GEORGIA–PENINSULAR FLORIDA, P-915 AND P-916, WEST FLORIDA OFFSHORE, SHELF AND SLOPE

Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Miocene	Tamiami Formation	limestone and sandstone
	Hawthorn Formation	sandstone and clay
	Tampa Formation	sandy limestone
Oligocene	Suwanee Formation	limestone
Eocene	Ocala Formation	limestone
	Avon Park Formation	limestone
	Lake City Formation	limestone
	Oldsmar Formation	limestone
Paleocene	Cedar Keys Formation	dolomite and anhydrite
Mesozoic		
Cretaceous		
Late	Gulf Series	
	Lawson Limestone	limestone
	Atkinson Formation	limestone and shale
Early	Comanchean Series	
	limestone	limestone
	"upper anhydrite unit"	anhydrite
	Sunniland Limestone	limestone, dolomite
	Glades Creek Gp.	
	Punta Gorda Fm.	anhydrite
	Lehigh Acres Fm.	
	Able Mbr.	limestone, anhydrite
	Twelve Mile Mbr.	limestone, dolomite
	"brown dolomite zone"	
	West Felda Shale	shale
	Coahuilan Series	
	Fort Pierce Group	
	Pumpkin Bay Fm.	limestone, anhydrite, dolomite
	Bone Island Fm.	anhydrite, limestone, dolomite
Jurassic	Wood River Formation	anhydrite, dolomite, limestone, basal clastic unit
Triassic-Jurassic		rhyolite, basalt

P-150, BLACK WARRIOR BASIN

The Black Warrior basin is a triangular-shaped area located in northeastern Mississippi and northwestern Alabama. The basin extends over approximately 21,000 square miles. The Black Warrior basin is bounded on the north by the Nashville and Ozark domes, on the southeast by the Appalachian tectonic belt and on the southwest by the central Mississippi deformed belt. The sedimentary section is thicker than 20,000 feet in the deeper portion of the basin. The Black Warrior basin is currently a major producing area for natural gas, most of which is found above 6,000 feet, with only minor accumulations of oil. Recovery of natural gas associated with coal seams is becoming increasingly important.

In terms of exploration maturity, the Black Warrior basin can be divided into three areas: 1) the shallow northern and eastern portions of the basin, an area that is sparsely drilled and is considered to be immature with the potential for discovery of a number of fields of relatively small size because of both stratigraphy and depth; 2) the central portion of the basin, which is considered to be in early maturity, and holds the potential for several small- and moderate-size new field discoveries and a large number of field extensions; and 3) the southern, deeper portion of the basin which holds the potential for some intermediate- and large-size field discoveries. Sedimentary rocks in this area exceed 20,000 feet in thickness. Only seven wells have been drilled to a depth greater than 12,000 feet in the entire Black Warrior basin, and only four wells have been drilled below 15,000 feet. The interaction of structure, stratigraphy and diagenesis in the deeper portion of the Black Warrior basin is relatively unknown and will control the size and number of fields discovered.

Reservoir rocks. Production in the Black Warrior basin is primarily from Paleozoic clastics of the Mississippian Chester series. The sandstones of the Pennsylvanian Pottsville series also produce some hydrocarbons. Potential reservoir rocks range from Precambrian to Pennsylvanian age and consist of sandstones, limestones, dolomite and chert.

Traps. Hydrocarbon traps in the Black Warrior basin are primarily combination traps involving anticlines, faulted anticlines, high-angle normal faults and stratigraphy. Channel and bar sandstones provide stratigraphic traps in the Chester and Pottsville series. Stratigraphic traps usually have a structural component. Porosity variations in the carbonate sequences provide potential traps for hydrocarbons alone or in combination with structure and faulting.

Potential source rocks. The Mississippian Chester series is thermally mature to very mature and provides sources for both gas and oil. The thermally mature Pennsylvanian Pottsville series and the mature to very mature Ordovician Black River group would probably be sources primarily for gas.

P-150, BLACK WARRIOR BASIN
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Black Warrior basin. They represent only a sampling of the fields within the province for which data are available. Data for these fields have been obtained from the American Gas Association Committee on Natural Gas Reserves and from private industry communication.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Corrinne	127,312	62,482
Star	17,494	22,345
Musgrove Creek	25,952	22,269
McCracken Mountain	13,747	18,699
Beaverton	23,000	16,178
McRaney	13,675	15,528
Splunge	12,888	11,160
Buttahatchie River	24,282	6,451

P-150, BLACK WARRIOR BASIN
Generalized Stratigraphic Section

AGE	FORMATION	NE Mississippi	NW Alabama	GENERAL LITHOLOGY
Cenozoic				
Tertiary				
Eocene	Claiborne Group			
	Cockfield Formation			sandstone
	Cook Mountain Formation			shale
	Sparta Sandstone			sandstone
	Tallahatta Formation			sandstone, shale
	Wilcox Formation			sandstone, shale
Paleocene	Midway Group			shale
Mesozoic				
Upper Cretaceous	Selma Group			
	Prairie Bluff Chalk			chalk
	Owl Creek Formation			marl
	Ripley Formation			shale
	Demopolis Chalk			chalk
	Mooreville Chalk --		Coffee Sand	chalk, sandstone
	Eutaw Formation			shale, sandstone
	Tuscaloosa Group			sandstone
Lower Cretaceous	undifferentiated			
Paleozoic				
Pennsylvanian				
			Boyles Sandstone	sandstone
	Pottersville Formation			sandstone, shale
Mississippian				
Chester Series			Parkwood Formation	shale, sandstone, limestone
			Gardner Ss. Mbr.	
		Buskirk Sandstone	Gilmer Ss. Mbr.	
		Millerella Limestone	Millerella Ls. Mbr.	
		Carter Sandstone	Bangor Ls. Mbr.	
		Sanders Sandstone		
		Rea Sandstone		
		Abernathy Sandstone		
		Neal Black Shale	Hartselle Sandstone	
	Floyd Shale			shale
	Evans Ss. Mbr.			sandstone
	Lewis Sandstone			sandstone
Meramac Series	Tuscumbia Limestone			limestone
	Ft. Payne Formation			chert
Devonian	undifferentiated			
Silurian	undifferentiated			
Ordovician	undifferentiated			
Cambrian	undifferentiated			

P-910 AND P-911, ATLANTIC OFFSHORE, SHELF AND SLOPE

These provinces cover the entire Atlantic offshore area of the United States. Major tectonic features include the Yarmouth arch, Georges Bank basin, Southeast Georgia Embayment, the Carolina trough and platform, Blake Plateau basin, South Florida-Bahamas basin, and the Peninsular arch of Florida. No natural gas or oil production has been established in the province, although the existence of moderate quantities of gas has been established in at least one area. The accumulation of gas discovered was not sufficient to warrant installation of production facilities. Even though results to date have not been encouraging, numerous concepts and plays remain unevaluated and present some possibility for the existence of natural gas resources. Considering the size of the Atlantic offshore area and the sparsity and uneven distribution of wells, the province must still be considered immature from the standpoint of exploration. If production is established, the fields would have to be intermediate to large size in order to justify commercial development.

Potential reservoir rocks. Sedimentary rocks, mainly of Mesozoic to Tertiary age, are 30,000 feet or more thick. Sandstones and limestones are the major potential reservoir rocks. Limestones are more important in the southern portion of the province and perhaps are more important in the farther offshore areas of the Slope Province.

Traps. A large variety of trapping mechanisms have been postulated to occur, including most principal types of both stratigraphic and structural traps. Carbonate environments, including reefs if present, could include stratigraphic traps due to reef structures and permeability changes. Truncations and pinchouts may be related to some clastic reservoirs. Salt domes are also believed to be present. Structural traps may include both faults and folds.

Potential source rocks. Potential source rocks in the central portion of both provinces are anticipated to be more favorable for natural gas generation than for oil. Prospects for oil generation, along with gas, are more favorable in the northern (Georges Bank) and southern (Southeast Florida Shelf) regions.

P-915 AND P-916, WEST FLORIDA OFFSHORE, SHELF AND SLOPE

The western Florida shelf extends about 150 miles into the Gulf of Mexico. Many of the stratigraphic units of onshore peninsular Florida extend into this offshore area. Cretaceous and Tertiary rocks comprise the majority of the 25,000-30,000 feet of sediment in this area. Carbonate rocks are the major constituent in most of the province. Clastic rocks were deposited in the north. Probability is good for continuation of trends from the eastern part of the Gulf Coast Province and the panhandle region of Florida; additionally, trends which are productive predominantly of oil in south Florida may also extend offshore and include some natural gas resources. No hydrocarbons are presently being produced in the province. The west Florida offshore area is extremely large and there is virtually no information available from drilling which is applicable to these provinces. If natural gas production is established in the area, it would be anticipated that the fields would be intermediate to large size.

Potential reservoir rocks. The southern part of the province, which lies in the South Florida basin, appears to offer prospects for large-scale production. The Lehigh Acres Formation (Lower Cretaceous) is the best prospect because of the thick and highly porous Brown Dolomite zone in the Twelve Mile Member. The Sunniland Formation, which is productive onshore, will not prove economically feasible offshore unless it has a thicker porous section than is found onshore. Other formations which are of lowermost Cretaceous and upper Jurassic age may prove to be productive, but to date the porosity and geochemistry found in these formations onshore have not been favorable.

In the northern portion of the province, there is potential for the extension offshore of the productive trends of southern Mississisppi, southern Alabama and northwestern Florida. Possible reservoir units in the area are the Upper Cretaceous Tuscaloosa Formation, the Lower Cretaceous Hosston Formation, and the Upper Jurassic Smackover Formation.

Traps. Possible trapping mechanisms include reefs in the Upper Cretaceous and porosity changes in carbonate and sandstone facies. Anticlines, faulted anticlines and salt domes may exist.

Potential source rocks. Likely source rocks for the southern part of the area are closely associated with the carbonate rocks which are also potential reservoir rocks. Potential source rocks for the northern part include the Tuscaloosa and Smackover Formations along with the Lower Cretaceous Gordo Formation and Jurassic Cotton Valley Formation.

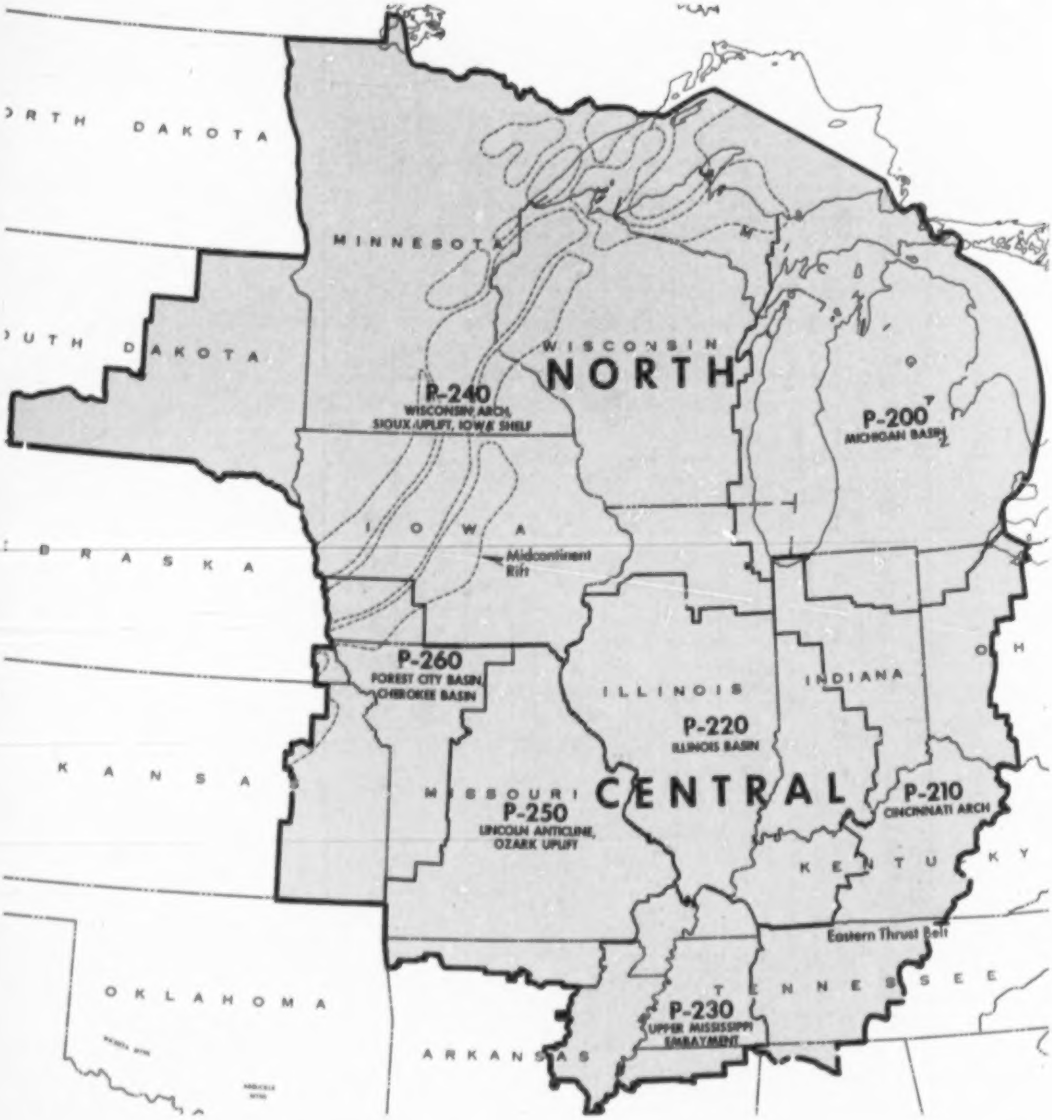
P-910 and P-911, ATLANTIC OFFSHORE, SHELF AND SLOPE
Generalized Stratigraphic Section

AGE	FORMATION		GENERAL LITHOLOGY
	North	South	
Cenozoic			
Pleistocene	Lauentian Formation	unnamed sands, silt and clay	sandstone, siltstone, clay
Pliocene-Miocene	Banquereau Formation		sandstone, siltstone, clay
Oligocene-Eocene-Paleocene	unnamed limestone	unnamed mudstone and chalk	limestone, mudstone, chalk
Mesozoic			
Late Cretaceoous	Dawson Canyon Fm.	unnamed siltstone and shale	shale, mudstone, siltstone
Early Cretaceous	Missisauga Fm. Baccaro ls.	unnamed sandstone, shale, limstone, evaporites	sandstone, limestone, siltstone, evaporites limestones
Jurassic	Mic Mac-Mohawk Fm. Mohican Fm. Iroquois Fm.		
Triassic	conglomerate Argo Salt	unnamed sandstone, siltstone, shale	conglomerate, sandstone, shale, siltstone
Paleozoic and Precambrian	metamorphic complex		

Table 11. Estimated resources of natural gas for provinces of the Atlantic Area, December 1984 (billion cubic feet)

PROVINCE	ONSHORE	OFFSHORE		PROBABLE			POSSIBLE			SPECULATIVE	
	depth	water depth	Max.	M. likely	Min.	Max.	M. likely	Min.	Max.	M. likely	Min.
P-100, New England and	0-15,000'								1,850	660	*
Adirondack uplift	15-30,000'								*	*	*
P-110, Atlantic Coastal	0-15,000'								1,450	440	*
basin	15-30,000'								*	*	*
P-120, Appalachian	0-15,000'		36,760	23,880	16,470	25,490	8,130	4,210	51,590	20,560	6,670
basin	15-30,000'								17,200	4,960	*
P-130, Piedmont-Blue	0-15,000'								5,980	2,070	500
Ridge province	15-30,000'								11,000	4,540	920
P-140, South Georgia-	0-15,000'								960	340	*
Peninsular Florida	15-30,000'								1,450	500	*
P-150, Black Warrior	0-15,000'		800	410	150	600	270	60	1,000	450	*
basin	15-30,000'					860	400	150	2,320	1,100	*
P-910, Atlantic shelf		0-200 m							22,000	9,000	*
P-911, Atlantic slope		200-1,000 m							11,000	4,200	*
P-915, West Florida shelf		0-200 m							10,000	2,250	*
P-916, West Florida slope		200-1,000 m							*	*	*
TOTAL onshore	0-15,000'			24,290			8,400			24,520	
TOTAL onshore	15-30,000'			*			400			11,100	
TOTAL onshore, all depths				24,290			8,800			35,620	
TOTAL offshore		0-200 m		*			*			14,790	
TOTAL offshore		200-1,000 m		*			*			660	
TOTAL offshore, all depths				*			*			15,450	
GRAND TOTAL FOR AREA				24,290			8,800			51,070	

*Negligible quantity of natural gas estimated


NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
ARKANSAS
MINNESOTA
WISCONSIN
IOWA
MISSOURI
ILLINOIS
INDIANA
OH
KENTUCKY
TENNESSEE
NORTH
CENTRAL
P-240
WISCONSIN ARCH, SIOUX UPLIFT, IOWA SHELF
P-200
MICHIGAN BASIN
P-260
FOREST CITY BASIN, CHEROKEE BASIN
P-250
LINCOLN ANTICLINE, OZARK UPLIFT
P-220
ILLINOIS BASIN
P-210
CINCINNATI ARCH
P-230
UPPER MISSISSIPPI EMBAYMENT
Midcontinent Rift
Eastern Thrust Belt

NORTH CENTRAL AREA

The estimated resource potential for the North Central area in the Probable and Possible categories occurs entirely in the Michigan basin. Potential resources in the Speculative category are also estimated to occur in the Michigan basin, and in addition are postulated for the Cincinnati arch province, the Illinois basin, the Upper Mississippi Embayment and the Forest City-Cherokee basins.

The Michigan basin has good exploratory potential for both structural and stratigraphic traps having small- to intermediate-size accumulations of gas. One or more giant fields is possible. The deep Cambro-Ordovician formations are now being tested in the basin. The Cincinnati arch province is generally well explored, but has the potential of the occurrence of small accumulations of either structurally or stratigraphically trapped resources. The Illinois basin is a maturely explored oil basin, and potential gas accumulations will likely be small. Many of the larger shallow structures have been tested into the older formations without encouragement. Devonian shale gas awaits technical and economic incentives for the development of this resource into intermediate-sized fields. The Upper Mississippi Embayment is an unexplored province with potential for intermediate-sized structural and stratigraphic traps. The Wisconsin arch-Iowa shelf is sparsely explored because of the relatively thin stratigraphic section consisting mostly of Paleozoic rocks. However, the postulated Mid-Continent Rift Zone indicated by geophysical information may contain intermediate to giant-sized structural traps. It has yet to be proven whether natural gas might be found in these traps. The Lincoln anticline-Ozark uplift province is a structurally high area with Precambrian rock outcrops and does not appear to have natural gas potential. The Forest City basin has been moderately drilled and explored. Potential traps may be either structural or stratigraphic with the accumulations of natural gas most likely to be of small size.

P-200, MICHIGAN BASIN

The Michigan basin geologic province includes the state of Michigan and portions of northern Indiana, northwestern Ohio, northeastern Illinois, and eastern Wisconsin. The province is bordered on the north and east by the Canadian border, on the west by the Wisconsin arch and on the south by the Kankakee and Findlay arches. The basin is an almost perfectly circular structural basin. Precambrian crystalline rocks outcrop around the northern rim of the basin. Erosion has not uncovered Precambrian rocks around the southern rim, but formations as old as Ordovician are exposed in Ohio and Indiana. In the center of the basin, Precambrian rock lies at a depth of 18,000 feet or more. The youngest widespread bedrock formations are Jurassic and Pennsylvanian sediments which occur toward the center of the basin. These bedrock formations are overlain by up to 1,200 feet of glacial sediments. The sedimentary rocks within the basin consist predominantly of Paleozoic carbonate rocks with some sandstones. Production of both natural gas and oil has been established from many fields within the basin.

A portion of the Speculative potential for the Michigan basin lies beneath waters of the Great Lakes (Maximum: 515 Bcf; Most likely: 254 Bcf; Minimum: 55 Bcf). These areas are currently withdrawn from exploration and development. The estimated potential for these offshore areas is included within the estimate for the total Michigan basin.

Reservoir rocks. Currently productive and potential reservoir rocks range from the early Ordovician (Prairie du Chien sandstones) to the Mississippian (Berea, "Stray" and Marshall Sandstones). Dolomites and sandstones are the principal potential reservoir rocks, and all potential reservoirs from the early Ordovician to the Carboniferous are already productive of gas or oil. Central basin formations of Silurian, early Ordovician and Cambrian age, including sandstones and dolomites, are potential reservoirs.

Traps. Reefs are common traps in Silurian (Niagaran) and in Devonian (Traverse) strata. Porosity and permeability variations also form traps in Ordovician, Devonian and Mississippian-Pennsylvanian lithologies. Anticlines and faulted anticlines form traps in Silurian, Devonian and Mississippian-Pennsylvanian beds. Secondarily dolomitized fracture trends accumulate major oil and gas reserves in middle Ordovician carbonates.

Potential source rocks. Potential source rocks for natural gas are predominantly Devonian shales and carbonate rocks (Antrim and Bell Shales, Traverse Group carbonates). The Salina A_1 Carbonate is the most likely source for Silurian reef gas accumulations. The Middle Ordovician Trenton-Black River carbonates are also considered to be a potential hydrocarbon source.

Producing trends. The Niagaran reef trend and the Albion-Scipio type fracture trends are the principal producing trends to date. Production generally is from less than 8,000 feet, although gas occurs in the Prairie du Chien at depths as great as 11,250 feet.

P-200, MICHIGAN BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Quaternary		glacial deposits
Mesozoic		
Jurassic		red beds
Paleozoic		
Pennsylvanian		sandstone, shale, coal
Mississippian	Michigan Formation	shale, anhydrite, dolomite
	"Stray" sandstone	sandstone
	Marshall Sandstone	sandstone
	Coldwater Shale	shale
	Berea Sandstone	sandstone
Devonian	Ellsworth-Antrim Shale	shale
	Traverse Group	limestone and shale
	Rogers City-Dundee Limestones	limestone-dolomite
	Detroit River Group	
	Lucas Formation	dolomite and evaporites
	Amherstburg Formation	limestone
	Sylvania Sandstone	sandstone
	Bois Blanc Formation	limestone
Silurian	Bass Islands Dolomite	dolomite
	Salina Formation	evaporites, shales and carbonates
	Niagara Carbonates	dolomite-limestones
Ordovician	Richmond Group	shales and carbonates
	Trenton-Black River Limestones	limestone
	St. Peter Sandstone	sandstone
	Prairie du Chien Group	dolomite and sandstone
Cambrian	Trempealeau Formation	limestone
	Munising Sandstone	sandstone
	Jacobsville Sandstone	sandstone
Precambrian		granite and crystalline rocks

P-210, CINCINNATI ARCH

The Cincinnati arch is a wide area of uplift which stretches from Ohio and Indiana southward through Kentucky and Tennessee into northernmost Alabama. The northern portion of the arch splits east and west into two branches which wrap around the southern end of the Michigan basin. The western branch is known as the Kankakee arch and the eastern as the Findlay arch. The southern end of the Cincinnati arch is somewhat separated from the remainder by an area in southern Kentucky, known as the Cumberland saddle, in which the axis of the arch plunges downward. The southernmost portion, south of the Cumberland saddle, is known as the Nashville dome. The Appalachian basin lies to the east and the Illinois basin to the west. The Cincinnati arch complex began its major upwarping in the Silurian Period. The crest is wide and the dips are exceptionally gentle. Most of the accumulations of gas and oil in western Ohio occur along the structurally highest part of the Findlay arch. Sedimentary rocks in the province range in age from Cambrian to Pennsylvanian and are relatively thin. Natural gas and oil production have been established in all of the states of this province.

The great Lima-Indiana field of eastern Indiana and western Ohio was discovered in 1884. Maximum production from this field was reached in 1896.

Reservoir rocks. Productive and potential reservoir rocks for gas and oil range in age from Cambro-Ordovician to Mississippian. The most common reservoir rocks are limestones and dolomites. Apart from the Devonian Salina-Niagaran Groups, all prospective reservoirs are already productive. The western Ohio fields on the Findlay arch produce chiefly from the Trenton Formation of Ordovician age. Trenton and Black River Limestones (Ordovician) are the principal reservoir formations in northern and eastern Indiana. Silurian carbonate rocks are the most prolific reservoirs in Kentucky, including the Lego (Louisville), Laurel and Brassfield, but production has also been found in Middle Devonian limestones and sandstones, the Ordovician Trenton-Black River-Chazy and the Cambro-Ordovician. Tennessee fields produce from Mississsippian, Silurian and Ordovician limestones.

Traps. Production in the Trenton-Black River Limestones is due to irregularly distributed dolomitization porosity enlarged by weathering before subsequent submergence. The principal traps in the Silurian reservoirs of Kentucky occur where porosity zones have been truncated by erosion and sealed by the deposition of the Devonian New Albany (Chattanooga) Shale immediately above the unconformity. Some Ordovician production is from fracture porosity, and there are some reef limestones encased in younger shales. Accumulation in Tennessee appears to be due to varying permeability within the reservoir rocks and to the presence of small folds.

Source rocks. Late Cambrian, Mississippian, and Pennsylvanian shales are considered to be fair to good sources for natural gas.

P-220, ILLINOIS BASIN

This province includes most of the state of Illinois and portions of western Kentucky and Indiana. The province is bounded on the north by the Kankakee arch, on the east by the Cincinnati arch complex and on the south by the Pascola arch. To the west the basin is bounded by the Mississippi River arch-Lincoln anticline. The province is predominantly an oil-producing province, but some natural gas is produced in small quantities. Sedimentary rocks consist primarily of Paleozoic sandstones and limestones which reach a thickness of at least 20,000 feet in the deepest part of the basin.

Reservoir rocks. Reservoirs for oil and gas exist in rocks of Cambro-Ordovician to Pennsylvanian age. Lithologies vary from sandstone to limestone and dolomite. Apart from the Cambro-Ordovician St. Peter and Knox Sandstones, all potential reservoir rocks are already productive of oil or gas. The principal production comes from the Mississippian Chester Sandstones, Ste. Genevieve, St. Louis and Salem Limestones, the Siluro-Devonian Hunton Limestone and the Ordovician Trenton-Galena Limestone.

Traps. Common trapping mechanisms include reefs, bioherms, porosity variations, anticlines, faulted anticlines and faults which occur throughout the stratigraphic section. Sandstone lenses, channels, and bars are important traps in the Mississippian units, whereas truncation by unconformity, onlap and porosity variations due to sedimentary diagenesis are prevalent in Pennsylvanian rocks as well as the Hunton and Ordovician Limestones.

P-220, ILLINOIS BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Paleozoic		
Pennsylvanian	Mattoon Formation	sandstone, shale
	Bond Formation	shale, limestone, sandstone
	Modesto Formation	shale, sandstone
	Carbondale Formation	shale, limestone, coal, sandstone
	Spoon Formation	sandstone, shale, coal
	Abbott Formation	sandstone
	Caseyville Formation	sandstone
Mississippian	Chesterian Series	sandstone, limestone, shale
	Valmeyeran Series	
	Aux Vases Formation	sandstone, limestone
	Ste. Genevieve Limestone	limestone
	St. Louis Limestone	limestone, dolomite
	Salem Limestone	limestone, dolomite
	Harrodsburg Limestone (Warsaw)	limestone
	Borden Formation (Osage)	limestone, shale, sandstone
	Kinderhookian Series	limestone, shale
Devonian	New Albany Shale	shale
	Lingle Formation (Cedar Valley)	limestone, dolomite, sandstone
	Grand Tower Formation	limestone, dolomite
	Dutch Creek Sandstone	sandstone
	Clear Creek Limestone	limestone
	Backbone Limestone	limestone
	Bailey Limestone	limestone
Silurian	Moccasin Springs Limestone	limestone
	St. Clair Limestone	limestone
	Kankakee Limestone	limestone
	Edgewood Dolomite	dolomite
Ordovician	Maquoketa Shale	shale, limestone
	Galena Limestone	limestone
	Platteville Limestone	limestone
	Joachim Dolomite	dolomite
	Dutchtown Limestone	limestone
	St. Peter Sandstone	sandstone
	Prairie du Chien Dolomite	dolomite
	Gunther Sandstone	sandstone
Cambrian	Eminence Dolomite	dolomite
	Potosi Dolomite	dolomite
	Franconia Limestone	sandy carbonates
	Galesville Shale	sandstone
	Eau Claire Formation	shale and carbonate
	Mt. Simon Sandstone	sandstone
Precambrian		crystalline rocks

Potential source rocks. Possible source rocks for both gas and oil range in age from Cambrian to Pennsylvanian. These are all thermally moderately mature to very mature and rate as fair to good potential gas and oil sources. Among the good potential sources are the late Ordovician Maquoketa Shale, the Devonian-Mississippian New Albany Shale, and other shale units within the Mississippian and Pennsylvanian sequences. Seeps, tar sands, and other shows are present.

P-230, UPPER MISSISSIPPI EMBAYMENT

This province includes portions of northeastern Kansas, southeastern Missouri, northern Mississippi, western Kentucky and western Tennessee. The province is bounded on the south by the Black Warrior and Desha basins, on the west by the Arkoma basin, on the north by the Illinois basin and on the east by the Nashville Dome. No gas or oil production has been established in this region to date. Sedimentary rocks in this province are predominantly Paleozoic sandstones and carbonate rocks which may reach a maximum thickness of 20,000 feet.

P-240, WISCONSIN ARCH, SIOUX UPLIFT AND IOWA SHELF

This province includes the states of Minnesota and Wisconsin and portions of South Dakota, Iowa and northern Illinois. The province is bounded on the north by the Canadian border, on the east by the Michigan basin, on the south by the Forest City basin, and on the west by the Siouxana and Chadron arches and the Williston basin. No production of natural gas or oil has been established to date. Sedimentary rocks are predominantly Paleozoic carbonate rocks and sandstones and probably are generally less than 15,000 feet thick. Recent exploration interest has been focused on the Mid-Continent Rift Zone which traverses the province from northeast to southwest. It is postulated that considerable thicknesses of sedimentary rocks were deposited along this tectonic trend in elongate fault-block basins which may contain potential reservoir and source rocks. The faulting which is associated with the rift zone may have originated in Precambrian time and continued to affect Paleozoic sedimentation as well.

P-250, LINCOLN ANTICLINE AND OZARK UPLIFT

This province includes portions of Missouri and northern Arkansas. It is bounded on the east by the Lincoln anticline/Mississippi River arch, on the south by the Arkoma basin and on the northwest by the Forest City basin. In total, it encompasses an area of more than 53,000 square miles. No production of natural gas or oil has been established. Sedimentary rocks of Paleozoic age predominate. In most places the section of sedimentary rocks is thin and basement rocks of Precambrian age are not deeply buried.

P-260, FOREST CITY BASIN AND CHEROKEE BASIN

This province includes an area of more than 63,000 square miles and covers portions of eastern Kansas, southeastern Nebraska, southwestern Iowa and northwestern Missouri. It is bordered on the southwest by the Nemaha uplift, on the southeast by the Ozark uplift, and on the east by the Mississippi River arch/Lincoln anticline. Currently non-associated gas production has been established in the Kansas portion of the Forest City basin and both oil and gas production in the Cherokee basin and the Missouri portion of the Forest City basin. Sedimentary rocks consist mainly of Paleozoic sandstones and limestones which are up to 20,000 feet thick.

Reservoir rocks. Production of natural gas and oil stems dominantly from Mississippian and Pennsylvanian sandstones and carbonate rocks. The Siluro-Devonian "Hunton" Limestone and the mid-Ordovician Viola/Simpson Limestones are productive of oil in the Forest City basin. Potential reservoir rocks range in age from Cambrian to Pennsylvanian. Sandstones and carbonate rocks are equally important as potential reservoirs.

Traps. Stratigraphic and structural traps are small, but equally abundant, in Pennsylvanian and pre-Pennsylvanian reservoirs. Stratigraphic trap types include porosity and lithology changes, onlaps, sandstone lenses, channels and bars. Structural trap types include both anticlines and faulted anticlines.

Potential source rocks. The thermally immature to mature Pennsylvanian Cherokee Shale and some Mississippian shales and limestones are thought to be good potential sources for both natural gas and oil. The same is true for the Devonian-Mississippian Chattanooga Shale which is thermally mature.

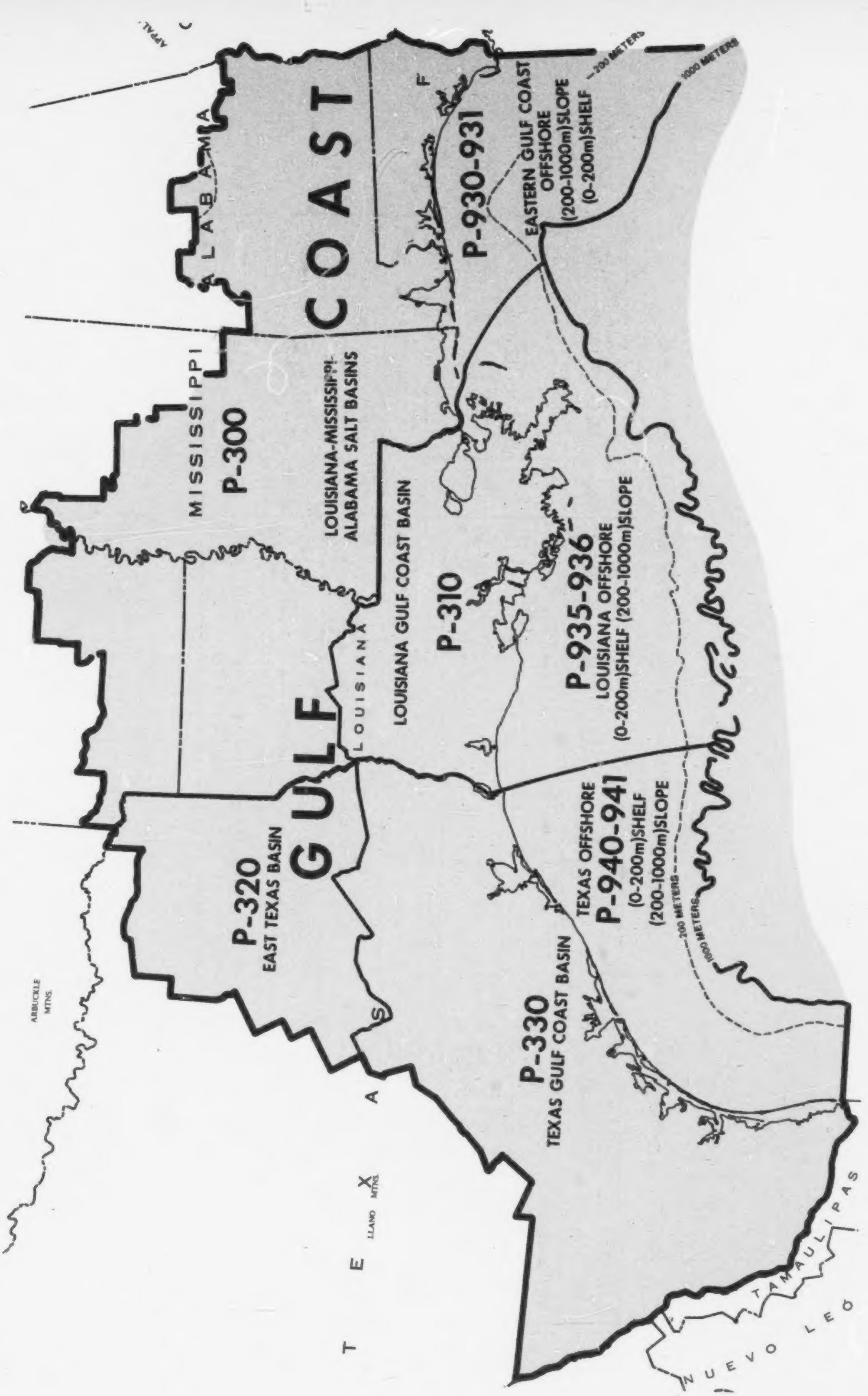
P-260, FOREST CITY AND CHEROKEE BASINS
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Paleozoic		
Permian		red beds and evaporites
	Chase Group	limestone and shale
	Council Grove Group	limestone
	Admire Group	shale, limestone, sandstone
Pennsylvanian	Wabaunsee Group	limestone and shale
	Shawnee Group	shale, sandstone, limestone
	Douglas-Pedee Groups	shale, sandstone
	Lansing-Kansas City Groups	limestone, sandstones, shales
	Pleasanton Group	sandstone and limestone
	Marmaton Group	limestone, shale, sandstone
	Cherokee Group	sandstone and shale
	Atokan Group	limestone and shale
	Morrowan Group	shale, limestone, sandstone
Mississippian	"Mississippi Lime"	limestone
Mississippian-Devonian	Chattanooga Shale	shale
Siluro-Devonian	"Hunton" Limestone	dolomite
Ordovician	Maquoketa Shale	shale
	Viola Limestone	limestone and sandstone
	Simpson Sandstone	sandstone
Cambro-Ordovician	"Siliceous Lime"	dolomite
	Reagan Sandstone	sandstone
Precambrian		granite and crystalline rocks

Table 12. Estimated resources of natural gas for provinces of the North Central Area, December 1984 (billion cubic feet)

PROVINCE	ONSHORE	OFFSHORE		PROBABLE			POSSIBLE			SPECULATIVE	
	depth	water depth	Max.	M. likely	Min.	Max.	M. likely	Min.	Max.	M. likely	Min.
P-200, Michigan basin	0-15,000'		145	72	17	3,678	2,250	845	1,005	461	84
	15-30,000'								*	*	*
P-210, Cincinnati arch	0-15,000'								7,139	2,499	1,428
	15-30,000'								*	*	*
P-220, Illinois basin	0-15,000'								15,610	4,900	1,350
	15-30,000'								*	*	*
P-230, Upper Mississippi	0-15,000'								4,220	1,450	450
Embayment	15-30,000'								*	*	*
P-240, Wisconsin arch,	0-15,000'								*	*	*
Sioux uplift, Iowa shelf	15-30,000'								*	*	*
P-250, Lincoln anticline,	0-15,000'								*	*	*
Ozark uplift	15-30,000'								*	*	*
P-260, Forest City basin,	0-15,000'								1,500	1,000	500
Cherokee basin	15-30,000'								*	*	*
TOTAL, onshore	0-15,000'			72			2,250			10,310	
TOTAL, onshore	15-30,000'			*			*			*	
TOTAL, onshore, all depths				72			2,250			10,310	
GRAND TOTAL FOR AREA				72			2,250			10,310	

*Negligible quantity of natural gas estimated


GULF COAST
ALABAMA
MISSISSIPPI
P-300
LOUISIANA-MISSISSIPPI ALABAMA SALT BASINS
LOUISIANA
LOUISIANA GULF COAST BASIN
P-310
P-930-931
EASTERN GULF COAST OFFSHORE (200-1000m)SLOPE (0-200m)SHELF
200 METERS
1000 METERS
P-935-936
LOUISIANA OFFSHORE (0-200m)SHELF (200-1000m)SLOPE
TEXAS OFFSHORE
P-940-941
(0-200m)SHELF (200-1000m)SLOPE
P-320
EAST TEXAS BASIN
P-330
TEXAS GULF COAST BASIN
TEXAS
ARBUCKLE MTNS.
LLANO MTNS.
TAMAULIPAS
NUEVO LEO
APPAL.
F

GULF COAST AREA

All of the geologic provinces of the Gulf Coast Area are productive of natural gas and oil. This region is the dominant producing area of natural gas in the United States. Much of the area is in a mature exploration stage, but important new fields continue to be discovered. Many of the reservoir rocks are highly porous and permeable and capable of delivering high volumes of gas. Much of the major natural gas pipeline system is designed to transport gas from this area to northern and eastern regions of the country.

P-300, LOUISIANA-MISSISSIPPI-ALABAMA SALT BASINS

This region is bounded on the northwest by the Ouachita Mountains and on the northeast and east by the Paleozoic Black Warrior basin and southern extent of the Eastern Thrust Belt. It contains three structural uplifts: the Sabine uplift, the LaSalle uplift, and the Monroe uplift. Other structural elements in the area include the Jackson Dome, an igneous intrusion in central Mississippi; the Hatchtigbee anticline; and the Pickens-Gilbertown-Pollard fault zone which is an extension of the Mexia-Talco fault zone of the East Texas basin. Northeast-southwest trending faults flank the east side of the Sabine uplift. The region contains more than 80 salt domes, and has many other salt-deformation-related features. It is a region of major production of oil, non-associated gas and associated/dissolved gas. A wide belt of gas fields extends from high on the Monroe uplift to the Texas border.

Reservoir rocks. Reservoir rocks range in age from Jurassic to Miocene. Tertiary reservoir rocks are undifferentiated Miocene zones, the Eocene Cane River Formation of the Claiborne Group, and the Wilcox Formation. Upper Cretaceous reservoir units are the Taylor and Navarro Formations of the Selma Group, the Austin Chalk and Eagle Ford Shale of the Eutaw Formation and the Tuscaloosa Group. Productive Lower Cretaceous intervals are the Washita Formation, the Paluxy, Rodessa, James Lime, Sligo, and Hosston Formations of the Trinity Group. The upper Jurassic reservoir rocks are the Cotton Valley Group including the Schuler Formation, the Smackover Formation and Norphlet Formation. The Upper Cretaceous units are the most prolific reservoirs in the northern portion of the province. In the Louisiana portion, the Wilcox is the most prolific unit. The Sligo and Hosston Formations are important gas horizons in the sub-basin between the Sabine and Monroe uplifts. The Monroe "Gas Rock" of the Selma Group is the major gas producer on the Monroe uplift.

Traps. Trapping in the region is largely associated with salt deformation. This includes salt domes, truncations, sandstone onlap on to structures, and anticlines. Fault associated traps are very important around salt domes, around the Jackson dome, along the east side of the Sabine uplift, and in the Pickens-Gilbertown-Pollard fault zone. Production from fault traps is frequently on the upthrown block. Lenticular sandstones are common throughout the region. Reefs occur in the Washita Formation. A major regional unconformity exists between the Upper Cretaceous and Lower Cretaceous. Several smaller unconformities also form traps in the province.

Source rocks. Source rocks range in age from Tertiary to Jurassic. Tertiary source rocks are the Claiborne Group, Wilcox Formation, and Midway Formation. Cretaceous source rocks include the Selma Group, Eutaw Formation, Tuscaloosa Group and Hosston Formation. Jurassic source rocks include the Cotton Valley Group and Smackover Formation and downdip facies of the Norphlet.

Trends. Major producing trends in the area are located in the Wilcox, Tuscaloosa, Cotton Valley, Smackover and Norphlet Formations.

P-300, LOUISIANA-MISSISSIPPI-ALABAMA SALT BASINS
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Louisiana-Alabama-Mississippi Salt Basins province. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Thomasville	247,481	65,374
Greens Creek	100,467	80,450
Big Escambia	69,100	78,508
Chunchula	70,343	56,300
Hatters Pond	45,739	52,693
Waveland	123,314	23,936
Dexter	220,144	15,734
Hub	288,820	15,732
Baxterville	433,530	14,392
Jay	140,516	13,944
Gwinville	1,411,542	6,056
Knoxo	134,803	5,903
Soso	175,191	3,125
Sandy Hook	103,959	2,784
Pistol Ridge	363,744	2,600
Maxie	314,210	1,256

P-300, LOUISIANA-MISSISSIPPI-ALABAMA SALT BASINS
Generalized Stratigraphic Section

AGE	FORMATION		
	Louisiana	Mississippi	Alabama
Cenozoic			
Quaternary			
Pleistocene			
Tertiary			
Pliocene		Citronelle Formation	
Miocene		Pascagoula/Hattiesburg	
		Catahoula Sandstone	
Oligocene			Vicksburg Group
Eocene		Jackson Group	
	Claiborne Group	Claiborne Group	Claiborne Group
	Wilcox Group	Wilcox Formation	Wilcox Group
Paleocene	Midway Group	Midway Group	Midway Group
Mesozoic			
Cretaceous			
Late (Gulfian)	Selma Group	Selma Group	Selma Group
	Eutaw Group	Eutaw Formation	Eutaw Formation
	Woodbine Formation	Tuscaloosa Group	Tuscaloosa Group
Early (Comanchean)	Washita/Fredericksburg	Washita/Fredericksburg	L. Cretaceous undiff.
	Trinity Group	Trinity Group	
	Sligo Formation		
	Hosston Formation	Hosston Formation	
Jurassic	Cotton Valley Group	Cotton Valley Group	
	Smackover Formation	Smackover Formation	
	Norphlet Formauon	Norphlet Formation	
	Louann Salt	Louann Salt	
	Werner Formation		
Triassic	Eagle Mills Formation	Eagle Mills Formation	
Paleozoic			
Permian	Morehouse Formation		
Pennsylvanian			

P-310, LOUISIANA GULF COAST BASIN (ONSHORE)

The Louisiana Gulf Coast basin is one of the major oil and gas provinces in the United States. It is the lower part of the Mississippi Embayment. Most of the province is covered by Quaternary sediments, but Tertiary rocks outcrop in the northern portion. An extremely thick clastic wedge of fluvial and deltaic sediments was deposited. Regional structure is largely the result of differential sedimentation related to salt flowage and the associated contemporaneous faulting. Salt domes are abundant and both salt and sulfur are mined.

Reservoir rocks. South Louisiana produces from Tertiary through Cretaceous rocks. Tertiary reservoirs are mainly sandstones capped by shales of Miocene, Oligocene and Eocene age. Cretaceous reservoirs are largely oil-bearing carbonates, but significant gas is present in Tuscaloosa sands and Sligo carbonates. The thick Miocene wedge dominates South Louisiana in both oil and gas production.

Traps. The major trapping mechanisms in this province are faulted anticlines and salt domes. A high percentage of these traps are fault-related. Truncations with overlaps influence some reservoirs. Many strati-graphic traps, including updip porosity wedgeouts, occur in the Cretaceous carbonates.

Source rocks. Thick, organic-rich, Cretaceous and Tertiary shales provide ample sources for hydrocarbons in this prolific province.

Trends. Starting with the Lower Cretaceous in the northern portion of the province, the major trends parallel the coastline in bands of progressively younger sediments in the following sequence: Lower Tuscaloosa, Wilcox, Oligocene, Lower Miocene, Middle Miocene and Upper Miocene.

P-310, LOUISIANA GULF COAST BASIN (ONSHORE)
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Louisiana Gulf Coast basin (onshore). They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Lake Paige	1,008,036	126,680
Pecan Island	841,657	115,750
Garden City	1,506,569	92,904
Belle Isle	988,094	44,917
Hollywood	1,097,312	36,799
Lirette	923,048	33,558
Gibson	1,080,285	32,797
Deep Lake	890,194	29,600
Bayou Penchant	927,560	25,157
West Delta Block 27	2,347197	21,828
Lake Palourde, East	698,687	18,039
Krotz Springs	1,119,168	14,428
Rayne	762,417	7,550

P-310, LOUISIANA GULF COAST BASIN (ONSHORE)
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Quaternary		
Pleistocene		
Tertiary		
Pliocene		
Miocene	Fleming Formation	shale, sandstone
	Upper	
	Middle–"Harang"	
	Lower–"Abbeville"	
Oligocene	Anahuac Formation	shale, sandstone
	Frio Formation	sandstone, shale
	"Hackberry"	
	"Shuteston"	
	Vicksburg Group	sandstone, shale, marl
Eocene	Jackson Group	sandstone, shale
	Yazoo Formation	shale
	Moody's Branch Marl	marlstone
	Claiborne Group	sandstone, shale
	Cockfield Formation	sandstone and shale
	Cook Mountain Formation	shale
	Sparta Formation	sandstone
	Cane River Formation	shale
	Wilcox Group	sandstone, shale
Paleocene	Midway Group	sandstone, shale
Cretaceous		
Late	Selma Group	limestone and sandstone
	Eutaw Group	sandstone and shale
	Tuscaloosa Group	sandstone
Early	Washita/Fredericksburg	limestone
	Trinity Group	sandstone, shale, anhydrite, limestone
	Sligo Formation	limestone
	Hosston Formation	sandstone and shale

P-320, EAST TEXAS BASIN

The East Texas basin, or Tyler basin, occupies northeastern Texas. It is bounded on the north and west by the Ouachita Tectonic Belt and is separated from the North Louisiana basin to the east by the Sabine uplift. The Angelina-Caldwell flexure separates it from the Texas Gulf Coast basin to the south. The East Texas basin is part of the Mississippi Embayment. Upper Cretaceous rocks outcrop in the western and northwestern portions of the basin. Progressively younger rocks outcrop to the south and east. The two most prominent structural features in the basin are the Mexia-Talco fault system which parallels the Ouachita Tectonic Belt on the west and north margins of the basin and the Sabine uplift to the east. The Mexia-Talco system extends eastward into the Louisiana-Mississippi-Alabama salt basin. The Mt. Enterprise fault system extends westward from the southern flank of the Sabine uplift to near the central portion of the basin. Several regional unconformities occur in this basin. There are also numerous salt domes, salt anticlines and related residual or "turtle back" structures.

Reservoir rocks. Production ranges in age from Jurassic to Eocene. The only Tertiary production is from sandstones in the Wilcox Group. The Upper Cretaceous production is from the Taylor Group, the Austin Chalk, the Eagle Ford and Woodbine Groups. Lower Cretaceous reservoir rocks are the Buda Formation of the Washita Group, members of the Fredricksburg Group, the Paluxy Formation, members of the Glen Rose Formation, the Rodessa and James Formations of the Glen Rose Group and the Pettet and Travis Peak Formations of the Nuevo Leon Group. Jurassic reservoir rocks are both sandstones and limestones in the Cotton Valley Group and the Smackover Formation. Paleozoic sandstones and limestones are potential reservoirs in the northern and western portions of the basin.

Traps. Combination structural-stratigraphic traps are very common throughout the province and affect most of the stratigraphic intervals. Anticlines, faulted anticlines and faults are the most common structural mechanisms, particularly in the Woodbine and Smackover. High energy sand and carbonate facies, in combination with various structures, form traps in the Tertiary, Upper and Lower Cretaceous units and portions of the Jurassic. Reef facies form traps in the James Limestone. Salt domes are less important as traps in the basin. Local and regional unconformities also form traps, the most notable of which is the East Texas field.

Source rocks. It is likely that the source rocks for this province are shales that are adjacent to the various reservoirs. Limestones in parts of the area are possible sources as are transgressive shales overlying unconformities.

Trends. Notable trends in this basin are the Mexia-Talco Fault zone, the Smackover trend which generally parallels the Mexia-Talco trend but lies farther downdip and two Cotton Valley Limestone trends, one of which occurs in an arcuate pattern around the western flank of the Sabine uplift and the other trends along the southwestern portion of the basin. Most of the major Upper and Lower Cretaceous producing formations occur basin-wide and are not situated in trends.

P-330, TEXAS GULF COAST BASIN (ONSHORE)

The Texas Gulf Coast basin covers 67 counties of southern and southeastern Texas. It encompasses part of the Mississippi Embayment and part of the Rio Grande Embayment. It is bounded on the north and west by the Balcones Fault zone and Ouachita Tectonic Belt. Much of the production in this region is from Tertiary reservoirs. This is one of the major hydrocarbon regions of the United States. Both associated/dissolved and non-associated gas are produced in this region.

Reservoir rocks. Tertiary reservoir rocks are the Fleming, Anahuac, Frio, Vicksburg, Jackson Group, Claiborne Group, Wilcox Group and Midway Group. The Frio is the leading reservoir in the southern Gulf Coast area. Upper Cretaceous reservoir units include the Navarro Formation, Taylor Group, Austin Chalk, Eagle Ford Formation and Woodbine Formation. Lower Cretaceous reservoir rocks are the Buda and Georgetown Limestone Members of the Washita Formation, the Edwards Limestone and Paluxy Members of the Fredericksburg Formation, the Rodessa Member of the Glen Rose Formation and the Sligo Limestone. All productive formations produce both oil and gas except the Lower Cretaceous Sligo and Glen Rose Formations which produce only gas.

P-320, EAST TEXAS BASIN

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the East Texas basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Carthage	6,963,045	375,101
Opelika	820,881	176,032
Bethany East	133,454	35,535
Reed (Haynesville)	N/A	30,495
Blocker	26,379	14,922
Bear Grass	14,086	13,007
Reed, North	9,662	11,223
Fruitvale, East	30,382	9,807
Glenwood	3,379	8,771
Teague, South	10,151	7,407
Red Oak	22,141	7,239
Aker	3,997	6,996
Naconiche Creek	6,596	5,665
Simsboro, North	12,390	4,424
Pine Hill, Southeast	15,419	3,038
Carthage, Southeast	24,803	3,027
Scottsville, North	24,485	2,517
Trinidad, South	12,109	2,342
Allentown	14,191	1,111
Huxley	15,431	243
Mt. Selman	14,937	135
Red Lake	22,618	222

P-320, EAST TEXAS BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Tertiary		
Eocene	Claiborne Group	sandstone and shale
	Wilcox Group	shale and sandstone
Paleocene	Midway Group	shale and sandstone
Mesozoic		
Cretaceous		
Late (Gulfian)	Navarro Formation	sandstone and shale
	Taylor Formation	limestone
	Austin Formation	shale, limestone, sandstone
	Eagle Ford Shale	shale
	Woodbine Sandstone	sandstone
Early (Comanchean)	Washita Formation	limestone and shale
	Fredericksburg Limestone	limestone
	Trinity Group	
	Glen Rose Formation	limestone, shale, anhydrite
	Travis Peak Formation	sandstone and shale
Jurassic	Cotton Valley Group	sandstone, limestone, shale
	Buckner Formation	limestone
	Smackover Formation	limestone
Triassic (?)	Eagle Mills Formation	salt and shale

Traps. Anticlines, domes, diapirs and faults are the most common trapping mechanisms in the region and affect all productive intervals. Salt diapirs are more common in the northern portion, whereas shale diapirs are more common in the southern portion. Stratigraphic traps are less common, but sandstone lenses, sandstone pinchouts across structures and updip pinchouts do exist in the region. Overpressured reservoirs exist on shallow salt domes as well as at deeper levels. Some Frio structures host in excess of 50 sandstone reservoir units. Reefs occur in the Cretaceous, producing primarily non-associated gas.

Source rocks. All intervals from Tertiary to Lower Cretaceous contain likely source rocks. Most of these are bituminous shales, but limestones and chalks are also sources in the region.

Trends. Numerous trends exist in this province. They lie subparallel with both the Ouachita Tectonic Belt and the present day coast and overlap one another. Proceeding from west to east are: the Cretaceous trend, the Wilcox trend, the Queen City-Yegua trend, the Vicksburg-Frio trend and the Miocene trend, which extends offshore. The Cretaceous Edwards reef trend overlaps the Eocene Wilcox trend.

P-330, TEXAS GULF COAST BASIN (ONSHORE)
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Texas Gulf Coast basin (onshore). They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Stratton	1,081,215	28,154
Shipwreck	143,692	20,774
Santa Fe	110,999	19,193
Dilworth	182,778	18,795
Javelina-Rincon, North	123,892	17,164
Tulsita-Wilcox	870,033	16,720
Sejita	170,787	15,243
Burnell	682,115	15,181
Kelsey Deep	386,795	10,785
San Carlos	275,976	6,786
Redfish Reef, Southwest	103,657	6,621
Lake Creek	122,534	4,275
Markham North-Bay City North	638,290	3,550
Kelsey, South	147,078	3,182
Clayton	234,815	2,379
Kelsey	171,088	1,325
Chevron	229,598	204

P-330, TEXAS GULF COAST BASIN (ONSHORE)
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Quaternary		
Pleistocene		
Tertiary		
Pliocene		
Miocene	Fleming Formation	shale, sandstone
Oligocene	Anahuac Formation	shale, sandstone
	Frio Formation	sandstone, shale
	Vicksburg Group	sandstone, shale, marl
Eocene	Jackson Group	sandstone, shale
	Claiborne Group	sandstone, shale
	Wilcox Group	sandstone, shale
Paleocene	Midway Group	sandstone, shale
Mesozoic		
Cretaceous		
Late (Gulfian)	Navarro Formation	shale, sandstone
	Taylor Group	chalk, marl, sandstone, silt
	Austin Chalk	chalk
	Eagle Ford Shale	shale
	Woodbine	sandstone
Early (Comanchean)	Washita Formation	limestone, shale
	Fredericksburg Formation-Edwards Limestone	limestone, dolomite
	Paluxy	shale, sandstone
	Trinity Group	
	Glen Rose Formation	limestone
	Pearsall Formation	shale, limestone
	Sligo Limestone	limestone, dolomite
	Hosston Formation	sandstone, limestone, dolomite
Jurassic	Cotton Valley Group	shale, sandstone
	Smackover Formation	limestone
	Norphlet Formation	sandstone, red beds
	Louann Formation	salt
	Werner Formation	anhydrite
Triassic	Eagle Mills Formation	sandstone, shale
Paleozoic		
Permian	Morehouse Formation	shale, sandstone
Pennsylvanian		

P-930 AND P-931, EASTERN GULF COAST OFFSHORE, SHELF AND SLOPE

The Eastern Gulf Coast shelf is a good potential area for exploration. The probabilty is high for continuation of trends offshore from Mississippi, Alabama and the Florida Panhandle. Discoveries to date have been confined to the area offshore from Mobile Bay.

Reservoir rocks. Possible reservoir rocks in this region are the Upper Cretaceous Tuscaloosa Formation, the Lower Cretaceous Hosston Formation and the upper Jurassic Cotton Valley Formation, Smackover Formation and Norphlet Formation. Minor Miocene reservoirs are also recognized at this time.

Traps. Anticlines, faults, faulted anticlines and deep-seated salt swells are the most likely traps in this area. Porosity changes are the most likely stratigraphic trap. Regional unconformities may also form traps in this area.

Source rocks. The most probable source rocks in this region are the Upper Cretaceous Tuscaloosa Formation, Lower Cretaceous Gordo Formation, the Jurassic Cotton Valley Formation and unrecognized downdip rocks.

P-935 AND P-936, LOUISIANA OFFSHORE, SHELF AND SLOPE

This region is the most prolific offshore area of the United States. The shelf is only twenty miles wide at the end of the Mississippi delta, but widens to 130 miles near the Texas Gulf Coast boundary. The upper slope, as well as the shelf, is very productive in this province. East-west trending fault zones probably extend from onshore out onto the shelf. Pressures encountered in the reservoirs may be much higher than normal.

Reservoir rocks. Reservoir rocks in this area are all sandstones. They range in age from Pleistocene through Miocene. Older units are buried to great depth and are not productive to date. Individual formation names are not applied in the offshore region. Paleontologic markers are the most commonly utilized means of identifying the stratigraphic units. Many of the units are debris flows and submarine fans.

Traps. Salt domes, growth faults and faulted anticlines are the most common trapping mechanisms in this region. Onlaps and truncations are very common. Porosity changes in the deeper reservoirs and lenticularity of the sand bodies form effective traps.

P-930 AND P-931, EASTERN GULF COAST OFFSHORE, SHELF AND SLOPE
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Eastern Gulf Coast Offshore Province. They represent only a sampling of the fields within the provinces for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Area and Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Lower Mobile Bay–Mary Ann	0	406,870
Exxon (State Lease 535, Tract 63)	0	150,000
Mobil (State Lease 528, Tract 72)	0	50,000

Source rocks. The source rocks for this region are bituminous shales ranging in age from Miocene through Pleistocene.

Trends. The Miocene-Pliocene Fleming Trend extends from onshore, continuing offshore, to near the shelf-slope break. The Pleistocene trend starts near the Mississippi River mouth and extends on down the continental slope.

P-935 AND P-936, LOUISIANA OFFSHORE, SHELF AND SLOPE

Selected Major Natural Gas Fields– Cumulative Production and Remaining Dedicated Reserves

Following are estimates of cumulative production and remaining reserves dedicated to interstate pipeline systems for selected major gas fields and areas in the Louisiana Federal offshore area. They represent only a sampling of the fields within the provinces for which data are available and for which it is indicated that the ultimate recovery of natural gas will be in excess of one trillion cubic feet. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves and are based on information from FERC Form 15 filings.

Area and Field	Cumulative Production (12/31/84) (million cubic feet)		Remaining Dedicated Reserves (12/31/84) (million cubic feet)	
West Cameron (87 fields)	10,238,505		2,408,890	
Block 180		1,063,591		180,802
Block 533		1,179,577		100,454
Eugene Island (62 fields)	8,608,552		2,276,147	
Block 292		1,122,029		179,322
Block 296		950,369		69,509
Block 330		749,222		245,006
Vermilion (62 fields)	9,275,822		2,209,690	
Block 14		2,739,148		281,574
Block 39		1,743,514		79,753
South Marsh Island (38 fields)	6,253,323		2,194,328	
Tiger Shoal		1,918,277		619,266
Block 48		951,629		171,357
Block 66		836,664		271,867
Ship Shoal (44 fields)	6,569,765		1,707,479	
Block 176		801,569		262,142
Block 208		911,213		210,836
East Cameron (50 fields)	5,334,423		1,402,168	
Block 64		1,221,119		81,116
South Timbalier (18 fields)	2,273,387		968,611	
Block 172		916,604		387,408
Grand Isle (9 fields)	2,428,277		746,693	
Block 43		1,041,506		471,501
South Pass (9 fields)	1,386,752		641,598	
West Delta (16 fields)	1,844,883		638,383	
Mississippi Canyon (7 fields)	241,523		550,378	
Main Pass (22 fields)	1,227,176		387,725	
South Pelto (7 fields)	289,266		177,984	
Bay Marchand (1 field)	1,587,578		12,010	

P-940 AND P-941, TEXAS OFFSHORE, SHELF AND SLOPE

The Texas offshore portion of the Gulf Coast is an important hydrocarbon province, and produces oil, associated/dissolved gas and non-associated gas. The production and potential in this region are excellent but are less than that for offshore Louisiana. There was less sand deposited, and the sand which was deposited here was finer-grained, in this region which was further from the Mississippi delta complex. Consequently, there is a higher percentage of shale in the section and the sandstone reservoirs tend to have lower porosity than counterparts in Louisiana. Many of the formations which are productive onshore continue offshore, including the Miocene trend. Present production is confined to the continental shelf.

Reservoir rocks. Producing units for the Texas Gulf shelf are not designated by formation names. They are simply referenced by geologic age. The productive units are Miocene and Oligocene sandstones.

Traps. Anticlines, faulted anticlines, salt diapirs, shale diapirs and growth faults are the major trapping mechanisms in this province. Stratigraphic traps include sandstone lenses, onlap, truncations, and porosity variations.

Source rocks. Miocene bituminous shales are the most likely source rocks for this province.

P-940 AND P-941, TEXAS OFFSHORE, SHELF AND SLOPE
Selected Major Natural Gas Fields–
Cumulative Production and Remaining Dedicated Reserves

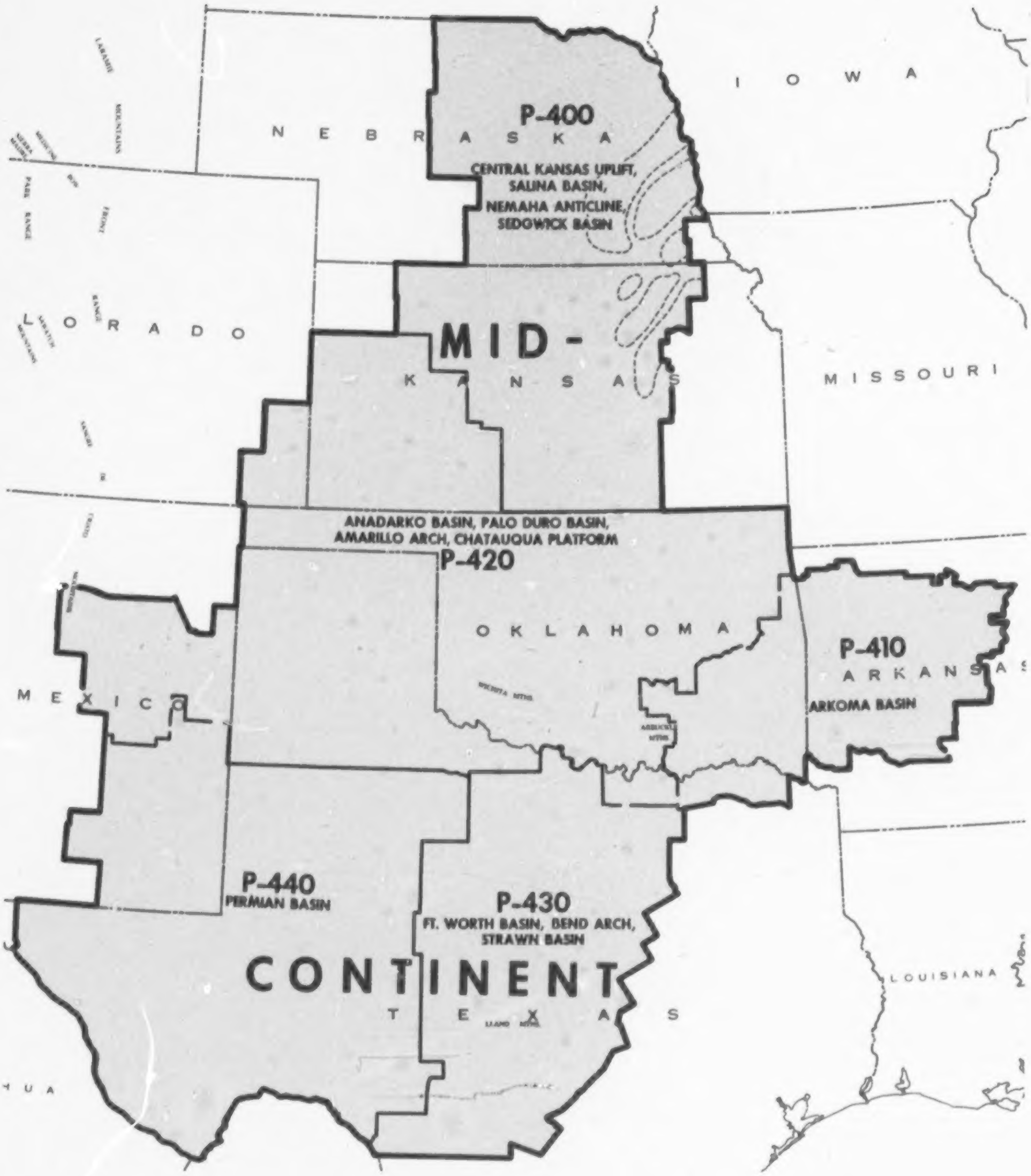
Following are estimates of cumulative production and remaining reserves dedicated to interstate pipeline systems for selected major gas fields and areas in the Texas Federal offshore area. They represent only a sampling of the fields within the provinces for which data are available and for which it is indicated that the ultimate recovery of natural gas will be in excess of five hundred billion cubic feet. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves and are based on information from FERC Form 15 filings.

Area and Field	Cumulative Production (12/31/84) (million cubic feet)		Remaining Dedicated Reserves (12/31/84) (million cubic feet)	
High Island (75 fields)	5,445,836		2,174,266	
Block 343		544,215		14,789
Block 370		1,113,185		100,189
Block 573		571,701		97,324
Brazos (17 fields)	553,024		753,444	
Matagorda Island (13 fields)	182,784		556,739	
Mustang Island (7 fields)	133,670		231,050	
Sabine Pass (7 fields)	175,138		199,854	
Galveston (9 fields)	82,838		62,435	
North Padre Island (2 fields)	47,552		59,034	

Table 13. Estimated resources of natural gas for provinces of the Gulf Coast Area, December 1984 (billion cubic feet)

PROVINCE	ONSHORE	OFFSHORE		PROBABLE			POSSIBLE			SPECULATIVE	
	depth	water depth	Max.	M. likely	Min.	Max.	M. likely	Min.	Max.	M. likely	Min.
P-300, Louisiana-Mississippi-	0-15,000'		4,000	3,300	2,475	8,125	6,500	3,900	7,800	6,000	2,400
Alabama salt basins	15-30,000'		1,620	1,350	880	11,750	9,700	4,850	12,000	9,500	3,800
P-310, Louisiana Gulf Coast	0-15,000'		3,540	2,980	2,060	3,800	2,960	880	*	*	*
basin (onshore)	15-30,000'		4,880	4,040	2,840	9,290	7,110	2,140	1,000	450	*
P-320, East Texas basin	0-15,000'		876	585	350	1,565	760	120	*	*	*
	15-30,000'		97	65	39	174	80	13	3,000	1,500	500
P-330, Texas Gulf Coast	0-15,000'		7,200	6,100	4,000	8,200	7,800	3,600	1,000	500	*
basin (onshore)	15-30,000'		5,500	4,350	3,200	7,200	5,200	4,000	1,200	500	250
P-930, Eastern Gulf shelf		0-200 m	9,000	2,000	1,750	15,000	7,000	2,000	14,000	8,000	3,000
P-931, Eastern Gulf slope		200-1,000 m				4,500	2,000	750	12,000	10,000	5,000
P-935, Louisiana shelf		0-200 m	20,600	18,100	10,900	31,000	18,000	4,600	*	*	*
P-936, Louisiana slope		200-1,000 m	2,500	1,400	400	22,700	12,900	3,800	1,000	500	*
P-940, Texas shelf		0-200 m	11,500	9,000	6,000	13,500	11,000	7,500	750	500	*
P-941, Texas slope		200-1,000 m	2,500	1,500	250	6,500	5,000	2,500	1,000	750	250
TOTAL, onshore	0-15,000'			12,965			18,020			6,500	
TOTAL, onshore	15-30,000'			9,805			22,090			11,950	
TOTAL, onshore, all depths				22,770			40,110			18,450	
TOTAL, offshore		0-200 m		29,100			36,000			8,500	
TOTAL, offshore		200-1,000m		2,900			19,900			11,250	
TOTAL, offshore, all depths				32,000			55,900			19,750	
GRAND TOTAL FOR AREA				54,770			96,010			38,200	

*Negligible quantity of natural gas estimated


I O W A
N E B R A S K A
P-400
CENTRAL KANSAS UPLIFT, SALINA BASIN, NEMAHA ANTICLINE, SEDGWICK BASIN
LORADO
MID-
K A N S A S
MISSOURI
ANADARKO BASIN, PALO DURO BASIN, AMARILLO ARCH, CHATAUQUA PLATFORM
P-420
O K L A H O M A
WICHITA MTNS
ARBUCKLE MTNS
P-410
A R K A N S A S
ARKOMA BASIN
M E X I C O
P-440
PERMIAN BASIN
P-430
FT. WORTH BASIN, BEND ARCH, STRAWN BASIN
CONTINENT
T E X A S
LLANO MTNS
LOUISIANA
HUA

MID-CONTINENT AREA

The Mid-Continent Area is, next to the Gulf Coast Area, the second most important area of current natural gas production in the country. The Area includes the Permian basin, the Anadarko basin and the extensive Hugoton-Panhandle area, all of which are important gas-producing areas and have great potential for future natural gas development. Additionally, the Arkoma basin and the Fort Worth basin-Bend arch-Strawn basin provinces are believed to have significant gas potential.

Almost all of the provinces of the Mid-Continent Area are in a mature stage of exploration. It is expected that most future fields to be discovered will fall into small or intermediate size categories. The two exceptions to this generalization are the deeper portions of the Anadarko basin and portions of the Arkoma basin where extensive exploration has not yet taken place.

P-400, CENTRAL KANSAS UPLIFT, SALINA BASIN, NEMAHA ANTICLINE AND SEDGWICK BASIN

This province covers eastern Nebraska and central Kansas. Paleozoic rocks outcrop in much of the region. Lower Cretaceous rocks cover part of the western portion and Cenozoic rocks mantle parts of Nebraska. It is primarily an oil province, but both non-associated and associated/dissolved gas are produced. Most of the production in this province is along the Central Kansas uplift. The Salina basin is the least explored portion of the region. Production is shallow--not more than 5,000 feet deep.

Reservoir rocks. Producing horizons range in age from Cambrian to Permian. The Cambrian-Ordovician Arbuckle Group is the major oil reservoir in the region. Most of the gas, however, is from upper Paleozoic units. Pennsylvanian age rocks are very important reservoirs. They include the Lansing-Kansas City Group, the Cherokee Group and basal sandstone/conglomerate. Other important reservoirs are the Permian Chase-Admire Group; the Mississippian "Mississippi Lime"; the Devonian Cooper Formation; the Silurian-Devonian "Hunton" Limestone; the Silurian Chimneyhill Limestone; the Ordovician Viola Limestone and Simpson Sandstone; and the Cambrian Reagan Sandstone.

Traps. Anticlines, faulted anticlines and domes form traps for all intervals throughout the province. Unconformity truncations affect Pennsylvanian and older units. In the Reagan Sandstone and Arbuckle Group, buried topographic relief provides a trapping mechanism. Traps are formed in lower Pennsylvanian units by onlap onto older structures. Variations in porosity affect both carbonate and sandstone units. Sandstones take the form of channel complexes, bars, and sheet sands.

Potential reservoir rocks. The province is dominated by carbonate rocks and shales, which form the source rocks of the area. Most of these are mature, though some of the younger units are immature. All of the Pennsylvanian shales and some of the limestones are considered source rocks. Other known source rocks are the Mississippian Chattanooga Shale, and the Ordovician Simpson Sandstone and Maquoketa Shale.

P-410, ARKOMA BASIN

This province covers southeastern Oklahoma, western and central Arkansas. It is primarily a gas province. The Oklahoma portion of the province was formerly known as the McAlester coal basin. The Arkoma basin is bounded on the north by the Ozark uplift, on the northwest by the Central Oklahoma platform and Seminole arch, on the west by the Arbuckle Mountains, on the south by the Ouachita Mountains, and on the east by the Mississippi Embayment. It is a Paleozoic basin containing more than 19,000 feet of Pennsylvanian and older rocks.

P-400, CENTRAL KANSAS UPLIFT, SALINA BASIN, NEMAHA ANTICLINE AND SEDGWICK BASIN

Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Mesozoic		
Late Cretaceous	Pierre Shale	shale
	Niobrara Formation	chalk, limestone
	Carlile Shale	shale, siltstone, sandstone
	Greenhorn Limestone	limestone, shale
	Graneros Shale	shale
	Dakota Formation	sandstone, shale
Paleozoic		
Permian	Nippewalla Group	shale, sandstone
	Sumner Group	shale
	Chase Group	limestone, shale
	Council Grove Group	limestone, shale
	Admire Group	limestone, shale
Pennsylvanian	Wabaunsee Group	limestone, shale
	Shawnee Group	limestone
	Douglas Group	shale, sandstone, limestone
	Lansing Group	limestone, shale
	Kansas City Group	limestone, shale
	Pleasanton Group	limestone, shale
	Marmaton Group	limestone, shale
	Cherokee Group	shale, limestone
	Atoka Formation	shale
Mississippian	Ste. Genevieve Limestone	limestone
	St. Louis Limestone	limestone
	Salem (Spergen) Limestone	limestone
	Warsaw Limestone	limestone
	Keokuk-Burlington Limestone	limestone
	Chauteau Group	
	Hannibal Shale	shale
	Gilmore City Limestone	limestone
	Hampton Group	limestone
	Boice Shale	shale
	North Hill Group	limestone
Devonian	Grassy Creek Formation-"Chattanooga" Shale	shale
	Callaway Formation-Cedar Valley Formation	limestone
Silurian		
Ordovician	Maquoketa Formation	
	Kimmswick Formation	limestone
	Decorah Formation	limestone, shale
	Plattin Formation	limestone
	Platteville Formation	
	Joachim Dolomite	dolomite
	St. Peter Sandstone	sandstone
	Arbuckle Group	limestone
Cambrian	Lamotte Sandstone	sandstone

Much of the area of this province is considered to be in a mature stage of exploration, but there are some areas of the province which are more complex structurally which have not yet been explored extensively. These areas lie in the southern portion of the province. The southeastern portion of Oklahoma has not seen any major exploration to date and the area is considered largely untested.

Reservoir rocks. Most of the reservoirs are Pennsylvanian in age. Those of the Atokan Series are the major producers and most of these are lenticular sandstones. Both sandstones and limestones of the Morrowan Series form reservoirs in the region. Mississippian carbonate rocks and sandstones produce both oil and gas. Older units (Ordovician-Silurian) produce oil and gas from sandstone and carbonate reservoirs. Some reservoirs are as shallow as 400 feet.

Traps. Anticlines and faulted anticlines form traps for all intervals. Anticlines in the province are generally large. Some are up to 40 miles long and 12 miles wide with up to 3,000 feet of closure. Channel sands and deltaic complexes are the dominant trap in Des Moinesian and Atokan rocks. The Morrowan units are littoral marine facies.

Potential source rocks. All stratigraphic intervals (Ordovician-Pennsylvanian) provide mature source rocks for the province. Most of these are marine shales but limestones are sources for some reservoirs.

P-410, ARKOMA BASIN
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Arkoma basin province. They represent only a sampling of the fields within the province for which data are available. All of the listed fields are located in Oklahoma; no data are available for Arkansas fields. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Red Oak Norris	823,764	308,477
Kinta	581,884	237,127
Wilburton	744,302	228,930
Quinton South	409,909	121,613
McCurtain North	351,020	120,314
Brewer South	37,676	55,077
Cartersville	231,268	49,928
Featherston	65,999	34,395
Featherstone	30,122	26,170
Bokoshe South	53,342	25,131
Redland	42,095	20,396
Centrahoma	107,150	7,008

P-420, ANADARKO BASIN, PALO DURO BASIN, AMARILLO ARCH AND CHATAUQUA PLATFORM

This is one of the major gas provinces of the United States. Much of the gas is non-associated, but large quantities of oil and associated/dissolved gas are also produced. Most of the province is very productive. Non-associated gas is the main product in the western portion. Oil and associated/dissolved gas are the major constituents in the central and eastern portions of the region. There is very little production in the Palo Duro basin or Wichita Mountains, but the Palo Duro basin is a potential region.

The Anadarko basin is a northwest-southeast trending stratigraphic and structural basin. It is bounded on the north by the Cambridge arch-Central Kansas uplift, on the northeast by the Nemaha uplift, on the east by the Arbuckle Mountains, on the south by the Wichita Mountains and Amarillo uplift, on the west by the Cimarron uplift, and on the northwest by the Las Animas arch. The Anadarko basin is highly asymmetrical with the steep side next to the Wichita Mountains. The northwestern end of the basin is called the Hugoton Embayment. The Hugoton-Panhandle field complex covers all or parts of 18 counties in Texas, Oklahoma, Kansas, and Colorado. The deeper portion of the Anadarko basin may contain over 40,000 feet of sedimentary rocks. In the Hugoton area, production is from as shallow as 1,100 feet.

All rocks which overlie the Ordovician in the shallower portions of the Anadarko basin are considered to be mature exploration targets and it is expected that future new field discoveries would occur in comparatively small stratigraphic traps. Ordovician exploration at depths of 10,000 to 15,000 feet is relatively immature overall; most large structures have been drilled, but many smaller structures are untested. It is expected that Ordovician rocks at depths of 10,000 to 15,000 feet may yield small- and intermediate-sized fields in the future. The rocks below 15,000 feet in the Anadarko basin are still relatively unexplored, except for localized trends which occur just below 15,000 feet and which have reached mature stages of development. Both the Pennsylvanian clastic rocks and the older pre-Pennsylvanian carbonate rocks below 15,000 feet in the Anadarko basin may contain undiscovered fields with natural gas accumulations of over 150 billion cubic feet.

Reservoir rocks. Producing horizons range in age from Cambrian to Permian. The major reservoirs are mostly upper Paleozoic, including the Permian Leonardian and Wolfcampian Series rocks. Sandstones, conglomerates, limestones, and dolomites are all present in these Series. Wolfcampian carbonates of the Chase, Council Grove, and Admire Groups are the major reservoirs in the Hugoton field. Other important reservoirs in western Oklahoma and the Panhandle region include the Silurian-Devonian Hunton Limestone; the Mississippian "Chester" Limestone and Manning Limestone. In southeastern Anadarko basin, the upper Pennsylvanian Hoxbar Group is very productive. In central Oklahoma, the Atokan, Morrowan, and Springeran Series contain important sandstone and limestone reservoirs. Other productive upper Paleozoic intervals in the region are the Permian Clear Fork Group; the Pennsylvanian Cisco Series, Dornick Group, Deese Group, Marmaton Group including the Oswego Limestone, and Canyon Group (reef limestones and sandstones). Middle Paleozoic reservoirs include the Mississippian Sycamore Limestone and the Silurian-Devonian Bois d'Arc Limestone. Lower Paleozoic reservoirs include the Ordovician Sylvan Shale, Viola Limestone, and Simpson Group; the Cambro-Ordovician Arbuckle/Ellenburger Groups; and the Cambrian Reagan Sandstone.

Traps. In most of the province anticlines and faulted anticlines are important trapping mechanisms for middle and lower Paleozoic rocks. In the Palo Duro basin anticlines affect all productive intervals. Pennsylvanian sandstones consist of channel sandstones, delta complexes and littoral sand packages. Variations of permeability and updip pinchouts of permeability are common traps. In the Arbuckle Group some units have vuggy porosity. Unconformities truncate some reservoirs. Evaporites form seals for part of the Amarillo uplift. In the Quinduno field in Roberts County, Texas, tilting of oil/water and gas/oil contacts is caused by hydrodynamic pressures.

Potential source rocks. Source rocks are good to excellent in this province. They range from immature to over-mature depending on depth of burial. Probable source rocks include all Pennsylvanian shales and most Mississippian shales and limestones. Another likely source rock is the Devonian-Mississippian Woodford Shale.

P-420, ANADARKO BASIN, PALO DURO BASIN, AMARILLO ARCH, AND CHATAUQUA PLATFORM

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in this province. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Hugoton	27,595,537	12,783,962
Panhandle	36,404,033	2,185,244
Panoma	1,167,847	1,454,533
Mocane-Lavern	4,323,073	770,114
Geary Northeast	479,247	227,258
Reydon	396,990	264,999
Putnam	1,027,728	217,127
Minco Southwest	554,093	229,670
Greenwood	945,237	178,625
Camrick Gas Area	1,568,397	136,100
Hansford	1,348,549	158,733
Panhandle West (Red Cave)	600,984	154,188
Buffalo Wallow	595,049	101,020
Keyes Gas Area	501,567	89,492
Washita Creek	471,803	74,545
Ringwood	539,499	67,079

P-420, ANADARKO BASIN, PALO DURO BASIN, AMARILLO ARCH AND CHATAUQUA PLATFORM

Generalized Stratigraphic Section

AGE	TX-OK PANHANDLES	CENT.-W. OKLA.	SO. OKLA.
Mesozoic			
Cretaceous			
Late			Eagle Ford Shale
	Greenhorn Limestone		
	Graneros Shale		Woodbine Sandstone
	Dakota Sandstone		
Early	Kiowa Shale		Washita Gp.-ls., ss.
	Cheyenne Sandstone		Fredricksburg Gp.-ls.
			Trinity Gp.
Jurassic	Morrison Fm.-sh.		
Triassic	Dockum Fm.-ss.		
Paleozoic			
Permian	Quartermaster Fm.-ss.		
	Cloud Chief Fm.		
	Whitehorse Gp.-dol.		
	Blaine Fm.-ls.		
	Glorietta Sandstone		El Reno Gp.-ss., sh.
	Clear Fork Gp.-ls., ahy.		Hennessey Shale
	Wichita Fm.-ls.		Wellington Fm.-sh.
	Brown Dolomite		Chase Group-ls., sh.
			Council Grove Gp.-ls., sh.
			Admire Gp.-ls. sh.
Pennsylvanian	Wabaunsee Gp.-ss.		
	Shawnee Gp.-ss.		Cisco Gp.-ls., ss.
	Douglas Gp.-ss.		
	Lansing Gp.-ss., ls.	Ocheleta Gp.-sh.	
	Kansas City Gp.-ls., ss.	Skiatook Gp.-sh.	Hoxbar Gp.-ss.
	Pleasanton Gp.-ls., ss.		
	Marmaton Gp.-ss., ls.	Big Lime-ls.	Deese Gp.-ss., cgl.
	Cherokee Gp.-ss.	Oswego-ls.	
	Thirteen Finger Ls.		Upper Dornick Hills-ss.
	Morrow Fm.-sh., ss.	Morrow Fm.-sh., ss.	Morrow Fm.-sh., ss.
Mississippian	Springer Sandstone	Caney Sh.-sh.	
	Goddard Shale	Chester Ls.-ls.	
	Caney Fm.-sh.	Warsaw Ls.	
		Keokuk- Burlington Ls.	
		Fern Glen Ls.	
	Welden Fm.-ls.	Sedalia Fm.-ls.	
		Chauteau Ls.	
	Woodford Shale		
Silurian/Devonian	Hunton Gp.-ls.		
Ordovician	Sylvan Shale		
	Viola Ls.-ls.		
	Simpson Fm.-ss.		
	Arbuckle Gp.-ls., ss.	Ellenburger Ls.-ls.	
Cambrian	Reagan Sandstone		

P-430, FORT WORTH BASIN, BEND ARCH AND STRAWN BASIN

This province covers the central portion of Texas. It is bounded on the east by the Ouachita tectonic belt and on the south by the Balcones fault zone. It is primarily a Paleozoic province and Paleozoic rocks outcrop at the surface in the northern portion of the province. Lower Cretaceous rocks cover the Paleozoic sediments in the southern portion of the province. The province contains no giant fields. Exploration and development costs are low in the region due to shallow production (depths of 1,300 to 6,000 feet). This makes it an attractive drilling area. Both oil and gas are produced in this province and the gas occurs as both associated/dissolved and non-associated gas.

Reservoir rocks. Reservoir rocks range in age from Cambrian to Permian. Permian reservoirs include both sandstones and limestones of the Wolfcampian and Leonardian series. Limestone, sandstone and conglomeratic rocks form reservoirs in Pennsylvanian age units. Productive Pennsylvanian units include the Cisco, Canyon, Strawn, and Atokan Series. Mississippian reservoirs are limestones of the Barnett and Chappell Formations. Ordovician reservoirs are the Viola, Simpson, and Ellenburger Formations. Production from Cambrian age rocks is confined to the "granite wash".

Traps. Anticlinal trapping is important in this province. Some anticlines are very large but low. Closure may be only tens of feet, but fields may cover many square miles. Some anticlines are continuous through many units and unconformities, thus involving many pay zones. Eroded high-relief anticlines form traps for Cambrian and Ordovician units in some areas. Faulted anticlines are a common trapping mechanism in all intervals. Faults are important for some Cambrian oil accumulations. Many unconformities are present in the region. These form updip seals for some fields. Stratigraphic traps include sandstone lenses and pinchouts. Reefs and reefal facies are common. Fractured porosity forms traps in some lower Pennsylvanian carbonates. Combination traps are common.

Potential source rocks. Pennsylvanian and Mississippian units are the most common source rocks. They are all mature. They include the Pennsylvanian Smithwick and Comyn Shales; the Strawn Series; and the Mississippian Barnett Shale. Limestones in the region are possible source rocks.

P-430, FORT WORTH BASIN, BEND ARCH AND STRAWN BASIN
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in this province. They represent only a sampling of the fields within the province for which data were available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Boonsville (Bend Congl.)	2,129,575	700,000
Reno	33,008	20,873
X-Ray	110,429	7,908
Palo Pinto County Regular	43,122	7,075
Santa Anna	82,747	5,818
Stephens County Regular	31,739	5,492
Brown County Regular	27,479	4,638
Toto	41,608	3,967

P-440, PERMIAN BASIN

The Permian basin includes 51 counties in west Texas and 4 counties in southeastern New Mexico. All but 6 of these counties are currently productive of oil or gas, and the basin is a major oil and gas (both associated/dissolved and non-associated) province. Lea County, New Mexico is considered to be one of the richest oil-producing counties in the country.

The basin is bounded on the east by the Bend arch, on the north by the Amarillo-Ouachita uplift, on the west by the Sacramento Mountains, on the southwest by the Diablo platform, and on the south by the Marathon thrust belt. Sedimentary rocks within the basin are up to 25,000 feet thick in the deepest parts of the basin. Nearly all of the rocks are of Paleozoic age with a thin veneer of Mesozoic rocks at the surface. Carbonate rocks, both limestones and dolomites, are the dominant lithology. Thick bituminous shales and lenticular sandstones are interspersed with the carbonate rocks. Thick evaporite sequences were deposited during late Permian time.

Reservoir rocks. Reservoir rocks for oil and gas range in age from Cambrian through late Permian. Carbonate rocks form most major reservoirs, although lenticular sandstones produce in parts of the basin. Most production comes from the thick Permian section. Late Permian Guadalupian rocks, the shallowest reservoirs, have produced more than one-half of the oil produced to date in the basin. The Grayburg and San Andres Formations are the most prolific reservoir formations. Other important reservoirs are: Yates Formation, Glorieta Sandstone, Abo Shale, Spraberry Sandstone, Wolfcampian limestones, Cisco Group, Canyon Group, Strawn Group, Siluro-Devonian carbonates and Ellenburger Dolomite. Porosity ranges from vuggy to cavernous in shallower reservoirs to fracture porosity in deeper reservoirs and low permeability, tight, gas sands.

Traps. The major trapping mechanism in the province is anticlinal folds. Most anticlinal fields produce from several stacked reservoirs, some containing as many as 11 pay zones. The anticlines vary in size, but can be up to 16 miles by 6 miles (Eunice-Monument field). Reef and biohermal facies are the second most common trap. These include the Capitan reef (Guadalupian) and the Scurry reef (Pennsylvanian) of the Horseshoe Atoll. The Kelly-Snyder field covers 51,000 acres on the Horseshoe Atoll. The third most common trapping mechanism is the updip pinchout of lenticular sandstone bodies. Fault traps are rare. Some slump blocks form traps. In some parts of the province, buried topographic highs form reservoirs. Seals in the province include evaporites, shales and porosity loss due to facies changes within the carbonates.

Potential source rocks. Bituminous shales were deposited in the basin during Ordovician, Devonian, Mississippian, Pennsylvanian and Permian (Wolfcampian, Leonardian) time. These include the Woodford Shale, Barnett Shale, and Simpson Group. The shales are likely source rocks as are numerous carbonate facies throughout the province. All of the source rocks in the province are mature.

Future exploration. Present exploration is concentrated in the major producing areas. Gas exploration in the deeper portions of the Delaware and Val Verde basins is very promising. The Abo and Capitan reef complexes need further investigation. Additionally, since the majority of fields are contained in the Guadalupian rocks, all of the other known reservoir levels need further examination. The Ellenburger and underlying Cambrian sandstones are good prospective targets. The Precambrian, if highly fractured, could be productive in uplift areas such as the Central Basin platform.

P-440, PERMIAN BASIN

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Permian basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Texas		
Gomez	3,672,602	968,690
Ozona	388,882	746,404
Headlee	102,485	626,733
Sawyer	424,629	466,461
Puckett	2,324,776	356,511
Conger	161,020	352,906
Sand Hills	1,740,115	334,593
Block 16	1,018,256	181,380
Emperor	1,572,767	104,172
Brown Bassett	569,105	116,858
Waha	550,056	67,586
Lockridge	516,965	89,169
New Mexico		
Indian Basin	963,280	557,736
Eumont	2,008,236	417,338
Blinebry	1,065,605	198,994
Eunice-Monument	2,379,730	108,239
Drinkard	867,218	84,555

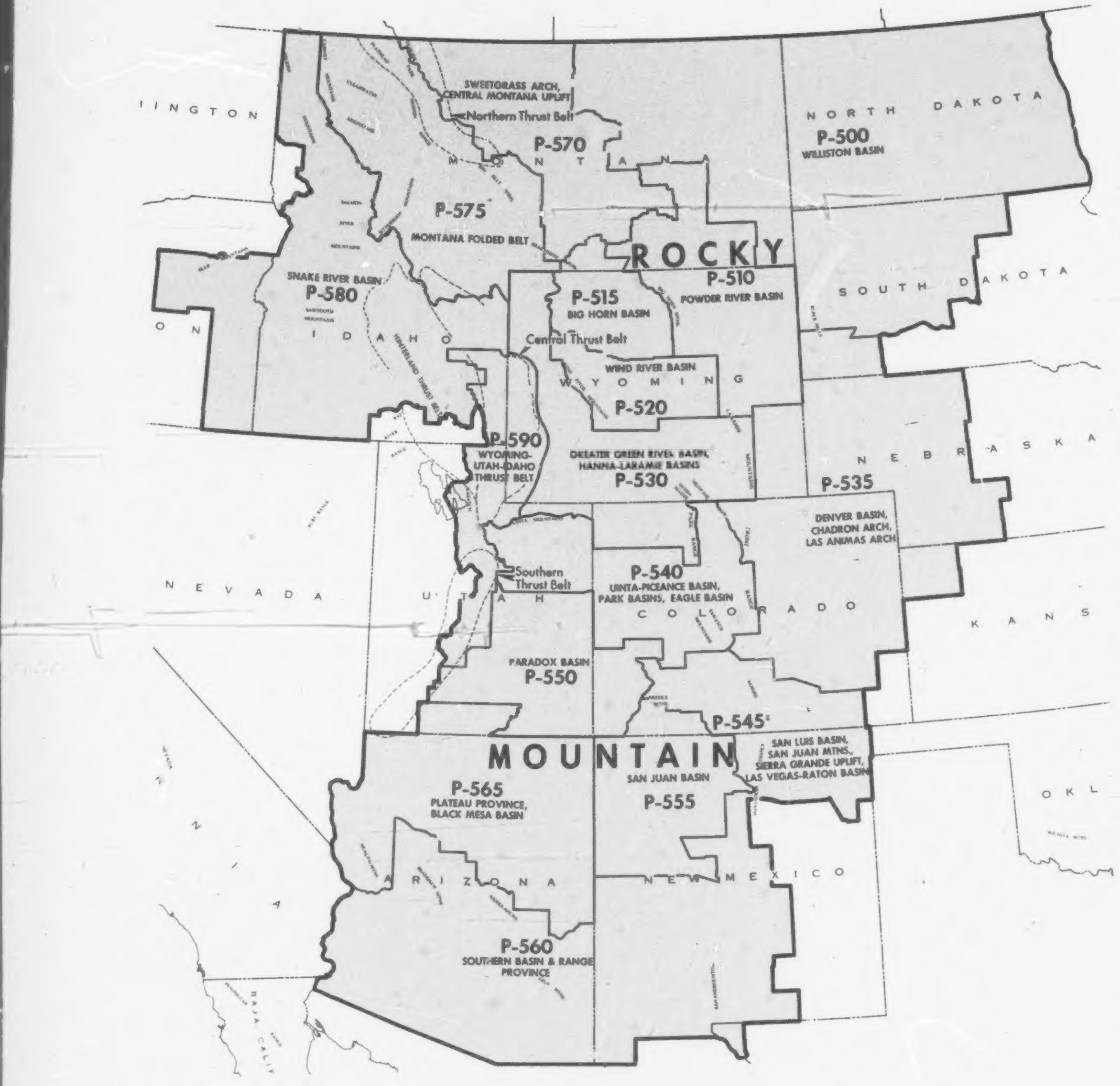
P-440, PERMIAN BASIN
Generalized Stratigraphic Section

AGE	FORMATION			GENERAL LITHOLOGY
	"Back Reef" Facies	"Reef" Facies	"Basin" Facies	
Mesozoic				
Early Cretaceous		Edwards Ls.		limestone
			Comanche Peak Ls.	limestone
			Paluxy Ss.	sandstone
		Trinity Ss.		sandstone
Paleozoic				
Permian	Ochoan Series			evaporites, shale, limestone, sandstone
	Guadalupian Series			
	Tansil Formation)	Capitan Ls.-)		limestone, dolomite,
	Yates Formation)	Bell Canyon)		sandstone,
	Seven Rivers Fm.)	Formation)	Delaware	evaporite
		)	Mountain	
	Queen Formation)	Goat Seep Ls.-)	Group	dolomite, sandstone
	Grayburg Fm.)	Cherry Cyn.)		
	San Andres Fm.)	Fm.)		
	Glorieta Sandstone	Brushy Cyn. Fm.		sandstone
	Leonardian Series			
	Clear Fork Grp.	Yeso Dolo.	Spraberry Ss.	carbonate, siltstone
	Abo Shale			shale
	Wolfcamp Group	Hueco Ls.		limestone and shale
Pennsylvanian	Cisco Group--Virgil Group)		Scurry	shale and limestone
	Canyon Group--Missouri Grp.)		Reef	shale and limestone
	Strawn Grp.--Des Moines Grp.)		ls.	limestone
	Atoka Group--Bend Group			limestone and shale
	Morrow Group			sandstone
Mississippian		Barnett Shale--"Helms fm."		shale
		Rancheria Fm.--"Mississippian ls."		limestone
		Kinderhook Formation		limestone
Devonian		Woodford Shale		shale
		Thirtyone Formation		limestone
Silurian		"Silurian ls."--Wristen Fm.		limestone and shale
		Fusselman Dolomite		dolomite and limestone
Ordovician		Sylvan Shale		shale
		Montoya Dolomite		dolomite and limestone
		Simpson Group		limestone, shale, sandstone
		Ellenburger Dolomite		dolomite
Cambrian		Bliss Sandstone		sandstone
Precambrian				

Table 14. Estimated resources of natural gas for provinces of the Mid-Continent Area, December 1984 (billion cubic feet).

PROVINCE	ONSHORE depth	OFFSHORE water depth	PROBABLE			POSSIBLE			SPECULATIVE		
			Max.	M. likely	Min.	Max.	M. likely	Min.	Max.	M. likely	Min.
P-400, Central Kansas	0-15,000'		600	400	300	200	100	100	*	*	*
uplift, Salina basin, etc.	15-30,000'								*	*	*
P-410, Arkoma basin	0-15,000'		1,365	1,160	750	1,260	1,070	700	1,835	1,560	1,000
	15-30,000'								*	*	*
P-420, Anadarko basin,	0-15,000'		31,500	19,900	11,600	29,600	16,600	7,600	41,900	23,000	9,900
Palo Duro basin, etc.	15-30,000'		11,000	8,500	7,000	89,000	36,000	20,000	98,000	32,000	4,000
P-430, Ft. Worth basin,	0-15,000'		3,000	2,300	1,500	2,500	2,000	900	1,000	800	100
Bend arch, Strawn basin	15-30,000'								*	*	*
P-440, Permian basin	0-15,000'		10,200	6,500	3,400	29,400	18,700	4,500	1,700	1,000	100
	15-30,000'		12,600	7,500	4,200	19,500	13,700	6,000	*	*	*
TOTAL, onshore	0-15,000'			30,260			38,470			26,360	
TOTAL, onshore	15-30,000'			16,000			49,700			32,000	
TOTAL, onshore, all depths				46,260			88,170			58,360	
GRAND TOTAL FOR AREA				46,260			88,170			58,360	

*Negligible quantity of natural gas estimated


ROCKY
MOUNTAIN
SWEETGRASS ARCH, CENTRAL MONTANA UPLIFT
Northern Thrust Belt
P-570
P-575
MONTANA FOLDED BELT
SNAKE RIVER BASIN
P-580
SAWTOOTH MOUNTAINS
SALMON RIVER MOUNTAINS
HINTERLAND THRUST BELT
P-500
WILLISTON BASIN
P-510
POWDER RIVER BASIN
P-515
BIG HORN BASIN
Central Thrust Belt
WIND RIVER BASIN
P-520
P-590
WYOMING-UTAH-IDAHO THRUST BELT
GREATER GREEN RIVER BASIN, HANNA-LARAMIE BASINS
P-530
P-535
DENVER BASIN, CHADRON ARCH, LAS ANIMAS ARCH
Southern Thrust Belt
P-540
UINTA-PICEANCE BASIN, PARK BASINS, EAGLE BASIN
PARADOX BASIN
P-550
P-545
SAN LUIS BASIN, SAN JUAN MTNS, SIERRA GRANDE UPLIFT, LAS VEGAS-RATON BASIN
P-565
PLATEAU PROVINCE, BLACK MESA BASIN
SAN JUAN BASIN
P-555
P-560
SOUTHERN BASIN & RANGE PROVINCE
UINTA MOUNTAINS
PARK RANGE
LARAMIE MOUNTAINS
SAN ANDRES MTNS
IINGTON
ON
NORTH DAKOTA
MONTANA
SOUTH DAKOTA
IDAHO
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANS
RNIA
ARIZONA
NEW MEXICO
OKL
BAJA CALIF

ROCKY MOUNTAIN AREA

The greatest potential for non-associated natural gas in the Rocky Mountain Area is concentrated in southwestern Wyoming and adjacent northwestern Colorado and northeastern Utah. This region includes the Greater Green River basin, the Uinta-Piceance basins and, to a lesser extent, the Wind River basin. All of these basins have a Tertiary and Cretaceous section containing large volumes of carbonaceous and coaly sediments in addition to marine sediments. Below a depth which generally corresponds to the 200° F. isotherm, the sediments tend to be over-pressured because gas is being generated and cannot escape from the low permeability sediments. The primary criterion for locating commercial gas production is finding a reservoir which is porous, permeable and continuous. Much of the gas which has been, and will be, found is in reservoirs which are classified as "tight." It is this poor reservoir character and continuity, for instance, as confirmed by recent drilling, that has caused the lowering of the 1984 estimate for the Wind River basin as compared to the 1982 estimate. The western Green River basin also includes the multi-trillion accumulation of low methane content, and, hence, low Btu, gas found in Paleozoic sediments on the Moxa arch. This accumulation extends into the Wyoming-Utah-Idaho Thrust Belt province beneath the thrusting.

The second province with major natural gas potential in the Rocky Mountain Area is the Wyoming-Utah-Idaho Thrust Belt. Large accumulations have been found in the Fossil basin area located in the southwestern corner of Wyoming and adjacent northern portions of Utah. The fields are primarily on the hanging wall of the Absaroka Thrust where early Mesozoic and Paleozoic reservoirs involved in complexly faulted anticlines have been thrust eastward over Cretaceous source sediments. The Mesozoic reservoirs tend to contain sweet gas and condensate; whereas, the Paleozoic reservoirs tend to contain sour gas and condensate. Reservoir sediments have been thrust over Cretaceous sediments in other portions of this province, but sufficient exploratory drilling has been done to show that numerous major accumulations comparable to those in the Fossil basin do not exist throughout the trend. For this reason, the 1984 estimate of natural gas resource potential in this province has been reduced compared to the 1982 estimate. The potential for gas from other possible source sediments and production from Cretaceous sediments is still speculative.

The Montana Folded Belt may contain accumulations resulting from geologic relationships which are grossly comparable to those existing, and postulated to exist, in the Wyoming-Utah-Idaho Thrust Belt. The Sweetgrass arch and Central Montana Uplift province contains numerous accumulations of associated and non-associated gas in a wide variety of structural and stratigraphic traps involving Paleozoic and Mesozoic reservoirs. The geologic variations found within this province leave adequate room for additional potential gas resources.

The Williston basin is primarily an oil province with most gas reserves and resources in the associated/dissolved category. Deeper accumulations within the basin tend to have higher gas/liquid ratios.

The Powder River basin of eastern Wyoming and Montana is also primarily an oil-producing region from Permo-Pennsylvanian and Cretaceous reservoirs. However, recent discoveries in the Amos/Andy area of Campbell County, Wyoming, are gas-condensate accumulations. Six fields, including Hilight, Kitty and Lance Creek, have produced in excess of 50 Bcf of associated gas. The Big Horn basin of Wyoming and Montana has potential for significant gas accumulations, primarily in Cretaceous sediments in the central, deeper portions of the basin, even though current production is primarily oil from Paleozoic reservoirs around the margins of the basin.

Most of the gas in the Denver basin is in one major non-associated accumulation in the Wattenberg area north of Denver. This accumulation is reservoired in the Lower Cretaceous "J" sand and is essentially in a stratigraphic trap on an old "paleo high." The extent of the fields is expected to expand with further development. The development of additional gas resources is anticipated in the Upper Cretaceous Hygiene, Niobrara and Codell-Timpas intervals, plus additional associated gas with "D" and "J" sand oil accumulations. Speculative resources are projected in younger Upper Cretaceous formations and in Paleozoic sediments.

The overlapping, multi-pay accumulations of gas in Upper Cretaceous sandstones which characterize the San Juan basin constitute the largest known reserve of gas in the Rocky Mountain Area. Potential resources, measured in trillions of cubic feet, are assigned to this basin.

Additional accumulations, comparable to those which have been found previously, are expected in the Paradox basin. Gas/liquid ratios are expected to be higher in the deeper parts of the basin. The Snake River basin, Black Mesa basin and the southern Basin and Range province are assigned small gas potential based on present information.

P-500, WILLISTON BASIN

This sedimentary basin covers more than 225,000 square miles in North Dakota, South Dakota, eastern Montana, southern Saskatchewan and southwestern Manitoba. It is bounded on the east by the Canadian Shield, on the southeast by the Sioux uplift, on the southwest by the Black Hills uplift and on the west by the Big Snowy uplift. Production occurs in all three states and both Canadian provinces. More than 16,000 feet of sediments lie in the deepest portion of the basin, and, of these, 5,000 to 7,000 feet are Paleozoic sediments, mostly carbonates and evaporites, and 6,000 feet are Mesozoic rocks, primarily clastics.

Reservoir rocks. Production occurs in reservoir formations ranging in age from Cambrian to Cretaceous. These productive units are the Cretaceous Colorado Group and Montana Group; the Permian-Triassic Spearfish Formation; the Pennsylvanian Tyler Formation; the Mississippian Big Snowy Group and Madison Group; the Devonian-Mississippian Bakken Formation; Devonian carbonate rocks; the Silurian Interlake Formation; the Ordovician Stony Mountain, Red River and Winnipeg Formations; and the Cambrian Deadwood Formation. Cretaceous Dakota Group sandstones, as well as sandstones in the Jurassic Swift Formation, are potential reservoirs for natural gas.

Traps. Anticlines and faulted anticlines provide traps for all stratigraphic intervals. Stratigraphic trapping is very important. Principal types of stratigraphic traps are porosity variations and truncations updip into impermeable units, such as evaporites. Next in importance are sandstone lenses and channels, found dominantly in the Big Snowy, Tyler and Lower Cretaceous units. Reefs, bioherms and buried topography form traps in the Red River, Interlake, Madison, and Devonian carbonate rocks. Combinations of these traps exist. Hydrodynamic trapping occurs in some anticlines in Montana.

Potential source rocks. Hydrocarbons in this basin were formed in numerous formations ranging in age from Cambrian to Paleocene. These formations include the Bakken, Red River, Winnipeg and Deadwood Formations, as well as the Paleocene Fort Union Formation; Upper Cretaceous Niobrara Formation; Lower Cretaceous Mowry Formation; Pennsylvanian Tyler Formation; Mississippian Heath and Lodgepole Formations; and Devonian Birdbear (Nisku) Formation.

Producing trends. The most noticeable structural feature in the province is the Cedar Creek anticline of southeastern Montana. This northwest-southeast-trending structure is over 100 miles long and contains up to 440 feet of productive section in lower Paleozoic carbonate rocks. Other major anticlines are the Bowdoin dome and Nesson and Billings anticlines.

P-510, POWDER RIVER BASIN

The Powder River basin is bounded on the east by the Black Hills, on the southeast by the Hartville uplift, on the south by the northwest end of the Laramie Range, on the west by the Casper arch and Big Horn Mountains, and on the north by the Miles City arch. This asymmetrical structural basin covers over 20,000 square miles. It is primarily an oil-producing basin, and natural gas represents a relatively minor portion of the basin's petroleum resources.

Reservoir rocks. Potential reservoir rocks range in age from Pennsylvanian to Cretaceous. Formations which are currently productive include the Upper Cretaceous Fox Hills Formation, Teapot Formation, Parkman Sandstone, Sussex Sandstone, Shannon Sandstone, Ash Creek Formation and

P-500, WILLISTON BASIN
Generalized Stratigraphic Section

AGE		FORMATION			GENERAL LITHOLOGY
		West		East	
Cenozoic					
Paleocene			Sentinel Butte Formation		shale, sandstone, coal
			Fort Union Formation		sandstone, shale, coal
Mesozoic					
Late Cretaceous		Hell Creek Formation			shale, sandstone
			Fox Hills Formation		sandstone
	Montana Group	Bearpaw Shale		Pierre Shale	shale
		Judith River Fm.			sandstone
		Claggett Formation			shale
		Eagle Formation			sandstone
		Telegraph Creek Formation			sandstone
	Colorado Group		Niobrara Formation		shale, marl, limestone
			Carlile Formation		shale
			Greenhorn Formation		shale, marl, limestone
			Belle Fourche Formation		shale
Early Cretaceous			Mowry Shale		shale
	Dakota Group	Muddy Sandstone		Newcastle Ss.	sandstone
		Skull Creek Formation			shale
		Kootenai Fm.		Inyan Kara Fm.	sandstone
			Fuson Mbr.		sandstone
			Lakota Mbr.		sandstone
Jurassic			Morrison Formation		shale
	Ellis Group	Swift Fm.		Swift Fm.	shale, sandstone, limestone
		Reirdon Fm.			shale, limestone
		Piper Fm.		Piper Fm.	shale, limestone
		Nesson Fm.			shale
			Dunham Salt		evaporites
Paleozoic					
Permian-Triassic			Spearfish Fm.		shale, sandstone
			Pine Salt		evaporites
Permian			Minnekahta Fm.		limestone
			Opeche Fm.		shale, evaporites
Penn. - Permian			Minnelusa Formation		sandstone, dolomite, shale
Pennsylvanian			Amsden Formation		dolomite, shale
			Tyler Formation		shale, sandstone
Mississippian	Big Snowy Gp.		Heath Formation		shale, sandstone
			Otter Formation		shale
			Kibbey Formation		sandstone, limestone
	Madison Gp.		Charles Formation.		evaporites
			Mission Canyon Fm.		limestone, shale
			Lodgepole Formation		limestone, shale

P-500, WILLISTON BASIN
Generalized Stratigraphic Section (continued)

AGE	FORMATION West	 East	GENERAL LITHOLOGY
Devonian-Miss.	Bakken Formation		shale
Devonian	Three Forks Formation		shale, evaporites
	Birdbear ("Nisku") Fm.	Duperow Fm.	limestone
	Souris River Formation		limestone
	Dawson Bay Fm.		limestone
	Prairie Fm.		evaporites
	Winnipegosis Fm.		limestone
	Ashern Fm.		dolomite
Silurian	Interlake Formation		dolomite, limestone
Ord.-Silurian	Stonewall Formation		dolomite, limestone
Ordovician	Stony Mountain Formation		limestone, dolomite
	Red River Formation		limestone, dolomite, evap.
	Winnipeg Formation		sandstone, shale
Cambro-Ordovician	Deadwood Formation		sandstone, shale

P-500, WILLISTON BASIN
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Williston basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Bowdoin	213,454	376,176
Cedar Creek area	87,253	43,671
Battle Creek	15,905	40,436
Red Wing Creek	7,116	24,551
West Shore Pine	7,118	11,637
Liscom Creek	2,723	7,447
Sawtooth Mountain	8,461	4,816
Bowes	36,692	3,411

Frontier Sandstone; the Lower Cretaceous Muddy-Dakota-Newcastle Formations, and Inyan Kara Group (Lakota Formation); the Jurassic Sundance Formation; and the Pennsylvanian Minnelusa-Tensleep Formations.

Traps. Anticlinal traps are common in the western portion of the basin. The central portion has buried topographic traps. The eastern portion is dominated by traps created by variations in the permeability of the reservoir rocks. Lenticular sandstones are found throughout the basin.

Potential source rocks. Organic-rich sediments were deposited at various times during the history of the region. Potential source rocks range in age from Pennsylvanian to Paleocene. They include the Paleocene Fort Union Formation; the Upper Cretaceous Lance, Lewis, Steele, Niobrara, Frontier and Greenhorn Formations; the Lower Cretaceous Mowry and Skull Creek Shales; the Jurassic Sundance Formation; the Permian Phosphoria Formation; and the Pennsylvanian Minnelusa Formation.

Potential for future exploration. The Powder River basin has good potential for future exploration. Large areas of the basin have not been explored. In the areas of the basin that have been explored, many potential reservoir rocks remain relatively untested. Many undiscovered stratigraphic traps are believed to exist.

P-515, BIG HORN BASIN

This province covers approximately 11,000 square miles in northern Wyoming and southern Montana. It is primarily an oil province and most gas occurs as associated/dissolved gas although non-associated gas is produced from Cretaceous and Paleocene Fort Union Formations. The basin is bounded on the west by the Absaroka Range and the Beartooth Mountains, on the south by the Owl Creek Mountains, on the east by the Big Horn Mountains and on the north by the Nye-Bowler lineament. The basin is covered by Tertiary continental sedimentary rocks which are as much as 8,000 feet thick. Mesozoic sedimentary rocks are up to 9,800 feet thick. The Paleozoic section is only approximately 2,300 feet thick.

Reservoir rocks. Potential reservoir rocks range in age from Cambrian to Paleocene. The most prolific reservoirs are the Permian Phosphoria Formation (Embar Limestone Member) and the Pennsylvanian Tensleep Formation. Other reservoir formations are the Paleocene Fort Union Formation; the Upper Cretaceous Lance Formation, Mesaverde Formation and Frontier Sandstone; the Lower Cretaceous Muddy, Dakota, Lakota and Fuson Formations; the Triassic Chugwater and Curtis Formations; the Pennsylvanian Amsden Formation (Darwin Sandstone Member); the Mississippian Madison Limestone; the Devonian Darby Formation; the Ordovician Big Horn Dolomite; and the Cambrian Flathead Sandstone.

Traps. The major trapping mechanism in the basin is anticlines and faulted anticlines, often combined with changes in porosity and permeability of reservoir formations. Many reservoirs demonstrate tilted oil/water or gas/water contacts due to hydrodynamic flow of water through the permeable formations. Channel and lenticular sandstones occur as well as facies changes in the carbonate reservoir rocks.

Potential source rocks. Potential source rocks occur at several stratigraphic levels, including the Paleocene Fort Union Formation; the Upper Cretaceous Lance, Mesaverde, Cody, Niobrara and Frontier Formations; the Lower Cretaceous Mowry and Thermopolis Shales; the Permian Phosphoria Formation; and in Upper Devonian rocks.

Future exploration. To the present time exploration has concentrated on anticlinal structures in the basin and the main target formations have been the Pennsylvanian-Permian units. Future targets include possible stratigraphic traps and the thick Mesozoic section, especially the various sandstones within the Mesaverde, Frontier and Dakota Formations.

P-510, POWDER RIVER BASIN

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Powder River basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves and private industry communication.

Field	Cumulative Production (12/31/84) (million cubic feet)		Remaining Proved Reserves (12/31/84) (million cubic feet)
Spearhead	32,057		6,762
Powell	N/A		886
Hilight	231,592	(12/31/83)	N/A
Lance Creek	141,829	(12/31/83)	N/A
Recluse	92,601	(12/31/83)	N/A
Kitty	80,707	(12/31/83)	N/A
Meadow Creek	78,581	(12/31/83)	N/A
Well Draw	57,407	(12/31/83)	N/A

P-515, BIG HORN BASIN

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following is the estimate of cumulative production and remaining proved reserves for the only major gas field in the Big Horn basin for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Dry Creek	65,556	5,532

P-520, WIND RIVER BASIN

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Wind River basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Madden (deep)	194,200	142,195
Long Butte	48,381	78,999
Pavillion	123,214	36,925
Riverton East	53,615	13,143
Muddy Ridge	20,130	9,857

P-510, POWDER RIVER BASIN
Generalized Stratigraphic Section

AGE	FORMATION		GENERAL LITHOLOGY
	West	East	
Cenozoic			
Oligocene	White River Formation		shale, conglomerate
Eocene	Wasatch Formation		conglomerate, sandstone, shale
Paleocene	Fort Union Formation		sandstone, shale, conglomerate
Mesozoic			
Cretaceous			
Late	Lance Formation		sandstone, shale
	Fox Hills Formation		sandstone
	Mesaverde Formation	Pierre Shale	shale, sandstone
	Lewis Shale Member		shale
	Teapot Sandstone Member		sandstone
	Parkman Shale Member		shale, sandstone
	Cody Shale	Steele Fm.	shale, sandstone
	Sussex Sandstone Member		sandstone
	Shannon Sandstone Member		sandstone
	"Ash Creek" Sandstone		sandstone
	Niobrara Formation		shale, marl, limestone
	Carlile Shale		shale
	Greenhorn Formation		shale, limestone
	Frontier Fm.	Bell Fourche Sh.	shale, sandstone
Early	Mowry Shale		shale
	Muddy Ss.	Newcastle Ss.	sandstone, shale
	Thermopolis Sh.	Skull Creek Sh.	shale
	Inyan Kara Group		shale, sandstone
	Fall River Fm.		shale, sandstone
	Lakota Fm.		sandstone
Jurassic	Morrison Formation		shale, sandstone
	Sundance Formation		sandstone, shale
	Gypsum Springs Formation		anhydrite, limestone, shale
Triassic	Chugwater Group–Spearfish Fm.		sandstone, shale, siltstone
Paleozoic			
Permian	Goose Egg Fm.–Minnekahta Ls.		shale, anhydrite, limestone
Permian-Penn.	Tensleep Sandstone	Minnelusa Fm.	sandstone, shale, dolomite
Pennsylvanian	Amsden Formation		limestone, sandstone
Mississippian	Madison Ls.–Pahasapa Ls.		limestone
Devonian	Jefferson Formation		limestone
Ordovician	Bighorn Dolo.	Whitewood Dol.	dolomite
Cambrian	Gallatin Limestone		limestone
	Gros Ventre Fm.	Deadwood Fm.	shale, limestone, sandstone
	Flathead Sandstone		sandstone

P-515, BIG HORN BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Oligocene	Wiggins-White River Formations	conglomerate, shale, sandstone
Eocene	Pitchfork Formation	sandstone
Paleocene-Eocene	Wasatch Formation	shale, sandstone, conglomerate
Paleocene	Fort Union-Polecat Bench Formations	shale, sandstone
Mesozoic		
Cretaceous		
Late	Lance Formation	shale, sandstone
	Meeteetse Formation	sandstone
	Mesaverde Formation	sandstone, shale
	Cody Shale	shale, sandstone, limestone
	Niobrara Member	limestone
	Frontier Formation	shale, sandstone, limestone
Early	Mowry Shale	shale
	Shell Creek Shale	shale
	Muddy-Dakota Sandstones	sandstone
	Thermopolis Shale	shale, sandstone
	Cloverly-Lakota- Fuson Formations	sandstone, shale
Jurassic	Morrison Formation	shale, sandstone
	Sundance Fm.-Ellis Group	sandstone, shale, limestone
	Gypsum Springs Formation	limestone, shale
Triassic	Chugwater Group	sandstone, shale
	Dinwoody Formation	shale, limestone
Paleozoic		
Permian	Phosporia-Park City Formations	shale, chert, limestone, sandstone
Pennsylvanian	Tensleep Sandstone	sandstone
	Amsden Formation	limestone, sandstone
	Darwin Sandstone Member	sandstone
Mississippian	Madison Formation	limestone, dolomite
Devonian	Three Forks-Jefferson-Darby Fms.	limestone, shale, dolomite
Silurian	Beartooth Butte Formation	shale, limestone
Ordovician	Leigh/Bighorn Dolomites	dolomite
	Gallatin Limestone	limestone
	Gros Ventre Formation	shale, limestone
	Flathead Sandstone	sandstone

P-520, WIND RIVER BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Oligocene	White River-Wiggins Formations	conglomerate, tuff
Eocene	Wagon Bed Formation	sandstone
	Wind River Formation	shale, sandstone, conglomerate
	Indian Meadows Formation	shale, sandstone
Paleocene-Eocene	Fort Union Formation	sandstone, shale
	Waltman Shale Member	shale
Mesozoic		
Cretaceous		
Late	Lance Formation	sandstone, shale, coal
	Meeteetse Fm. - Lewis Shale	sandstone, shale, coal
	Mesaverde Formation	sandstone, shale, coal
	Teapot Sandstone Member	
	Wallace Creek Member	
	Cody Shale	shale
	Phyles Sandstone Member	
	Niobrara Formation	shale, limestone
	Carlile Formation	shale, sandstone
	Frontier Formation	sandstone, shale
Early	Mowry Shale	shale
	Muddy - Dakota Sandstone	sandstone
	Thermopolis Shale	shale
	"Cloverly" Formation	sandstone, shale
	Lakota Sandstone Member	sandstone
Jurassic	Morrison Formation	shale, sandstone
	Sundance - "Curtis" Formation	sandstone, shale
	Gypsum Springs Formation	limestone, dolomite
Jurassic-Triassic	Nugget Sandstone	sandstone
Triassic	Chugwater Group	shale, sandstone, limestone
	Popo Agie Formation	shale
	Crow Mountain Formation	sandstone
	Alcova Limestone	limestone
	Red Peak Formation	shale
	Dinwoody Formation	dolomite, shale
Paleozoic		
Permian	Phosphoria - Park City - Goose Egg Fms.	limestone, shale, chert
	Ervay - Embar Limestone	limestone
Pennsylvanian	Tensleep Formation	sandstone
	Amsden Formation	dolomite, sandstone
	Darwin Sandstone Member	sandstone
Mississippian	Madison Limestone	limestone
Devonian	Darby Formation	dolomite
	Beartooth Butte Formation	shale, limestone
Ordovician	Bighorn - Leigh Dolomite	dolomite
Cambrian	Gallatin Group	limestone
	Gros Ventre Group	shale, limestone
	Flathead Sandstone	sandstone

P-520, WIND RIVER BASIN

This central Wyoming basin is bounded on the west and southwest by the Wind River Mountains, on the south by the Granite Mountains, on the north by the Owl Creek Mountains and the Washakie Range and on the east by the Casper arch. The basin covers approximately 8,500 square miles. Approximately three-fourths of the basin contains more than 20,000 feet of Paleocene-Eocene sedimentary rocks and up to 30,000 feet of total sedimentary section occurs in the deeper portions of the basin. The basin was emergent during much of Paleozoic time, thus very little Paleozoic section exists and there is nearly four times as much Mesozoic section as Paleozoic.

Structural features include a series of north-northwest-trending folds along the southern flank of the basin. Along the northern flank, rocks of the Owl Creek Mountains have been thrust southward over younger sedimentary rocks of the basin and on the east the Casper arch is thrust west over sedimentary rocks.

Natural gas in the Wind River basin occurs as both associated/dissolved gas and as non-associated gas. Most of the gas resource is non-associated. Many fields produce from multiple reservoir horizons.

Reservoir rocks. The major developed reservoir formation in the basin is the Pennsylvanian Tensleep Formation, but additional formations produce gas and/or oil in the basin, including the Tertiary Wind River and Fort Union Formations; the Upper Cretaceous Lance, Mesaverde, Cody and Frontier Formations; the Lower Cretaceous Muddy, Dakota, Cloverly-Lakota Formations; the Jurassic Morrison and Sundance - "Curtis" Formations; the Triassic Nugget and Crow Mountain Formations; and the Permian Phosphoria Formation (Embar Limestone Member). Many of the Tertiary and Upper Cretaceous reservoirs fall in the "tight" classification.

Traps. Anticlines and faulted anticlines form traps in all stratigraphic intervals. Sandstone channels and lenses are common. Porosity and permeability changes and pinchouts are also abundant in all intervals.

Potential source rocks. Potential source rocks range in age from Permian to Tertiary. They include the Tertiary Fort Union-Waltman Formations; the Upper Cretaceous Lance, Mesaverde, Cody, Niobrara and Frontier Formations; the Lower Cretaceous Mowry and Thermopolis Shales; and the Permian Phosphoria Formation.

Future exploration. The Wind River basin is in an intermediate stage of exploration. Potential targets exist in stratigraphic traps and in untested intervals within all parts of the stratigraphic section. Undiscovered traps and potential reservoirs exist along the northern and eastern flanks of the basin in sedimentary rocks beneath thrust faults.

P-530, GREATER GREEN RIVER BASIN, HANNA AND LARAMIE BASINS

The Greater Green River basin extends over portions of southwestern Wyoming, northeastern Utah and northwestern Colorado. The province includes several smaller basins in addition to the Green River basin proper: Red Desert basin, Washakie basin, Sand Wash basin, Hanna basin, Shirley basin and Laramie basin. The province is bounded on the west by the Utah-Wyoming-Idaho Thrust Belt, on the north by the Wind River and Granite Mountains, on the east by the Laramie Range and on the south by the Uinta Mountains and the Axial Basin anticline. The Green River basin proper contains over 20,000 feet of Paleocene-Eocene continental sedimentary rocks, and the total sedimentary section is over 30,000 feet thick.

Reservoir rocks. Potential reservoir rocks range in age from Cambrian to Eocene. The major producing formations are sandstones of the Tertiary Wasatch and Fort Union Formations, the Upper Cretaceous Lewis, Mesaverde Group (including the Almond), Frontier Sands, Dakota Group, the Juro-Triassic Nugget Sandstone and the Mississippian Madison Limestone. Other reservoirs include the Upper Cretaceous Lance-Fox Hills, Upper Cody, the Jurassic Morrison and Sundance, the Permian Phosphoria Formation, the Permo-Pennsylvanian Weber-Tensleep, the Pennsylvanian Amsden and Morgan Formations and the Cambrian Flathead Sandstone. Much of the Green River basin has potential for vast natural gas resources, but many potential reservoir rocks have low permeability.

P-530, GREATER GREEN RIVER BASIN, HANNA AND LARAMIE BASINS
Generalized Stratigraphic Section

AGE	FORMATION			GENERAL LITHOLOGY
	West		East	
Cenozoic				
Miocene	North Park Fm.		Browns Park Fm.	siltstone, sandstone, cong.
Oligocene		White River Formation		shale, arkose
Eocene	Bridger Fm.		Washakie Fm.	cong., sandstone, shale
	Green River Fm.		Wind River Fm.	shale, sandstone, oil shale
Paleocene-Eocene	Wasatch Fm.		Hanna Fm.	shale, sandstone
Paleocene	Hogback Fm.	Fort Union Fm.	Ferris Fm.	shale, sandstone, coal
Mesozoic				
Late Cretaceous	Lance Fm.		Medicine Bow Fm.	sandstone, shale, coal
		Fox Hills Sandstone		sandstone
		Lewis Shale		shale, sandstone
		Mesaverde Group		sandstone, shale, coal
		Almond Formation		sandstone
		Ericson Formation		sandstone
		Rock Springs Formation		sandstone
		Blair Formation		sandstone
	Hilliard Fm.	Baxter Shale	Steele Sh.	shale
		Niobrara Fm.		shale, marl
		Carlile Sh.		shale
		Frontier Fm.		sandstone, shale, limestone
		Greenhorn Ls.		limestone
		Belle Fourche Sh.		shale
Early Cretaceous	Aspen Sh.		Mowry Sh.	shale, sandstone
	Bear River Fm.			sandstone, shale
		Muddy Sandstone		sandstone
		Thermopolis Shale		shale
		"Dakota" Sandstone		sandstone
	Gannett Gp.	"Cloverly" Fm.		sandstone, shale
		Lakota Ss. Mbr.		sandstone
Jurassic		Morrison Formation		shale, sandstone
	Stump Fm.	Curtis Fm.	Sundance Fm.	sandstone, shale
	Preuss Ss.	Entrada Ss.		sandstone
	Twin Creek Ls.	Carmel Fm.		limestone, dolomite
		Gypsum Springs Fm.		limestone, dolomite
Triassic		Nugget Ss.		sandstone
		Ankareh Fm.		sandstone, shale
		Thaynes Ls.		limestone
		Woodside Fm.-Chugwater Gp.		shale, limestone
		Dinwoody Formation		limestone, shale

P-530, GREATER GREEN RIVER BASIN, HANNA AND LARAMIE BASINS
Generalized Stratigraphic Section (continued)

AGE	FORMATION			GENERAL LITHOLOGY
	West		East	
Paleozoic				
Permian	Phosphoria Fm.	Park City Fm.	Goose Egg Fm.	shale, limestone, chert
Pennsylvanian	Weber Ss.	Tensleep Ss.	Casper Fm.	sandstone
Miss.-Penn.	Amsden Fm.	Morgan Fm.		limestone, shale, sandstone
	Darwin Ss. Mbr.		Round Valley Ls.	limestone, sandstone
Mississippian		Madison Ls.		limestone
Devonian		Darby Fm.		dolomite
		Leigh Dolo.		dolomite
Ordovician		Bighorn Dolo.		dolomite
Cambrian		Gallatin Ls.		limestone
	Gros Ventre Fm.		Buck Spring Fm.	shale
		Flathead Ss.		sandstone

P-530, GREATER GREEN RIVER BASIN, HANNA AND LARAMIE BASINS
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Greater Green River basin, Hanna and Laramie basins. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Big Piney	1,861,214	1,919,368
Echo Springs	190,058	511,576
Moxa Arch area	124,295	414,964
Canyon Creek	228,798	100,915
Church Buttes	282,104	68,477
Hay Reservoir	40,681	65,320
East Hiawatha	195,941	55,517
Powder Wash	203,420	54,277
Trail	61,415	42,792
West Hiawatha	137,855	39,179
West Side Canal	128,905	36,958
Kinney	33,283	23,248
Sugar Loaf	65,575	23,064
Table Rock-Higgins	N/A	N/A
Desert Springs	N/A	N/A
Wamsutter	N/A	N/A

Traps. Anticlines and faulted anticlines provide traps for reservoirs of all ages. Together with these structural traps, sandstone pinchouts and permeability and porosity changes form the major trapping mechanisms.

Potential source rocks. Potential source rocks range in age from Permian to Eocene. They include the Eocene Wasatch and Green River Formations; the Paleocene Fort Union Formation; the Upper Cretaceous Lance, Mesaverde, Lewis, Baxter, Niobrara and Greenhorn Formations; the Lower Cretaceous Mowry-Aspen and Thermopolis Shales; Jurassic shales; and the Permian Phosphoria Formation.

Future exploration. The Greater Green River basin is still largely undeveloped. Although there is potential for major stratigraphic trapping, exploration will be difficult because of the stratigraphic nature of the trapping and the low permeability of many of the potential reservoir rocks. Thrusting of Precambrian rocks over the northern and southern margins of the basins, and lineaments could prove to be of exploration interest.

P-535, DENVER BASIN, CHADRON ARCH AND LAS ANIMAS ARCH

The Denver basin is an asymmetrical sedimentary basin lying in eastern Colorado, southeastern Wyoming, southwestern Nebraska, and northwestern Kansas. It is bounded on the west by the Front Range, on the south by the Apishapa uplift, on the southeast and east by the Las Animas arch and Cambridge arch, on the northeast by the Chadron arch, on the north by the Hartville uplift, and on the northwest by the Laramie Mountains. More than 13,000 feet of sediments, mostly of Cretaceous age, lie in the deepest portion of the basin below the city of Denver. This province also includes the Cañon City embayment which contains the second oldest oil field in the United States. Both associated/dissolved and non-associated gas is produced in the province.

Reservoir rocks. The major reservoir rocks in the Denver basin are the "D" and "J" sandstones of the Lower Cretaceous Dakota Group. Gas is produced more often from the "D" sand. The "J" sand is primarily an oil horizon but contains associated/dissolved gas as well. Upper Cretaceous sandstone-bar complexes of the Hygiene and Terry Members of the Pierre Shale produce oil in western parts of the basin. The Upper Cretaceous Niobrara Chalk produces non-associated gas on the eastern edge of the basin. The Upper Cretaceous Codell and Greenhorn Formations and the Permian Lyons Formation are also reservoirs in the basin. The large Wattenberg gas field is a tight-sand accumulation in both Upper and Lower Cretaceous units. Potential reservoirs exist in Mississippian and Pennsylvanian rocks. Along the Las Animas arch, Paleozoic rocks form the reservoirs. The Permian Stone Corral and Admire Formations are productive in this area, as well as Pennsylvanian sands and Mississippian and Pennsylvanian carbonate rocks.

Traps. The major trapping style in the basin is stratigraphic. Sandstone lenses and channel sandstone porosity pinchouts dominate. Fractured shales occur in the Niobrara and Pierre Formations in parts of the basin. Changes in facies with chalks account for the Niobrara play in the eastern portion of the basin. Biohermal and channel sand trapping occur along the Las Animas arch. Anticlines and faulted anticlines are confined largely to the western portion of the basin and Las Animas arch.

Potential source rocks. Cretaceous marine sediments are the primary source beds for the region, including the Denver, Pierre, Niobrara, Carlile, Bell Fourche, Graneros, Greenhorn, Skull Creek and Mowry Formations. Upper Paleozoic units are sources including the Pennsylvanian and Glen Eyrie Formations.

P-540, UINTA-PICEANCE BASIN, PARK BASINS AND EAGLE BASIN

This province contains six basins: Unita, Piceance, Eagle, North Park, Middle Park and South Park. Hydrocarbons produced in the region are oil, associated/dissolved gas and non-associated gas. Large amounts of both oil and gas are produced in the Uinta basin. The Piceance basin is dominantly a gas province and has the potential to be a nearly continuous gas field similar to the San Juan basin.

P-535, DENVER BASIN, CHADRON ARCH AND LAS ANIMAS ARCH

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Denver basin, Chadron arch and Las Animas arch province. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Wattenberg Muddy J	339,556	773,294
Niobrara	50,962	202,886
Spindle	198,186	55,478
Hambert	28,749	14,220

P-540, UINTA-PICEANCE BASINS, PARK BASINS AND EAGLE BASIN

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Uinta-Piceance basins, Park basins and Eagle basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Douglas Arch	294,310	450,114
South Canyon/Carbon	37,347	65,241
Piceance Creek	260,525	61,975
Plateau	15,468	33,608
Shire Gulch	3,520	27,650
Rulison	11,126	22,984
Southman Canyon	3,828	19,257
Bridle	8,241	14,094
Chapita	29,672	11,486
Divide Creek	26,974	6,593

P-535, DENVER BASIN, CHADRON ARCH AND LAS ANIMAS ARCH

Generalized Stratigraphic Section

AGE	FORMATION AND LITHOLOGY	
	West	East
Cenozoic		
Pliocene	Ogallala Fm.-ss, cong, ls	
Miocene	Arikaree Gp.-ss, silt	
Oligocene	White River Gp.-ss, cong, sh, silt	
Paleocene	Green Mountain Cong.- cong	
Late Cret.-Paleocene	Denver Fm.-ss, sh	Dawson Fm.-ss, sh
Mesozoic		
Late Cretaceous	Arapahoe Fm.-ss, cong	
	Laramie Fm.-sh	
	Fox Hills Fm.-ss	
	Pierre Sh.-sh, ss	
	Terry Ss. Mbr.-ss	
	Hygiene Ss. Mbr.-ss	
	Niobrara Fm.-sh, marl, ls, chalk	
	Benton Sh. Gp.-sh, ls, ss	
	Carlile Sh.-sh, ss	
	Codell Ss. Mbr.-ss	
	Greenhorn Fm.-sh, ls	
	Graneros Sh.-sh	Bell Fourche Sh.-sh
Early Cretaceous	Mowry Sh.-sh	
	Dakota Gp.-ss, sh	
	"D" Ss. Mbr.-ss	
	"J" Ss. Mbr.-ss	
	Skull Creek Sh. Mbr.-sh	
Jurassic	Morrison Fm.-sh, ss	
	Ralston Creek Fm.-sh	
	Entrada Ss.-ss	
Permian-Triassic	Lykins Fm.-sh, ls	Blaine Gyp.-evap
		Nippewalla Gp.-ss,sh
Paleozoic		
Permian	Lyons Fm. Satanka Sh.-ss, sh	Sumner Gp.-ls
	Ingleside Fm.-ls, sh	Chase-Council Grove Gp.-ls
		Admire Gp.-ls
Pennsylvanian	Fountain Fm.-arkose, ss, sh, ls	Waubaunsee Gp.-ls
		Shawnee Gp.-ls
		Douglas Gp.-ls
		Lansing-Kansas City Gps.-ls
		Pleasanton Gp.-ls
		Marmaton Gp.- ls
		Cherokee Gp.-ls
	Glen Eyrie Sh. Mbr.-sh	Atoka Gp.-ls
		Morrow Gp.-ls
Mississippian	Leadville Ls.-ls	St. Louis Ls.-ls
		Salem Fm.-ls
		Warsaw Fm.-ls
		Osage Gp.-ls
		Kinderhook Gp.-ls
Ordovician	Fremont Ls.-ls	
	Harding Ss.-ss	
	Manitou Ls.-ls	Arbuckle Gp.-ls
Cambrian	Peerless Dolo.-dol.	Reagan Ss.-ss
	Sawatch Quartzite-ss	

P-540, UINTA-PICEANCE BASINS, PARK BASINS AND EAGLE BASIN
Generalized Stratigraphic Section

AGE	FORMATION			GENERAL LITHOLOGY
	West		East	
Cenozoic				
Oligocene		Duchesne River Fm.		sandstone, shale
Eocene		Uinta Fm.		sandstone, shale
		Green River Fm.		shale, marl, oil shale
Paleocene-Eocene	Wasatch Fm.		Coalmont Fm.	sandstone, shale, coal
	Ohio Creek Fm.	Fort Union Fm.	South Park Fm.	sandstone, shale
Paleocene		North Horn Fm.		sandstone, shale
Mesozoic				
Cretaceous				
Late	Lance Fm.		Laramie Fm.	shale, sandstone, coal
		Fox Hills Fm.		sandstone
		Lewis Shale		shale
	Mesaverde Gp.	Mancos Sh.	Pierre Sh.	sandstone, shale, limestone
		Niobrara Fm.		shale, marl
		Carlile Sh.		shale
		Codell Ss. Mbr.		sandstone
		Greenhorn Ls.		limestone
		Frontier Fm.		sandstone, shale
Early		Mowry Shale		shale
		Dakota (Muddy) Ss.		sandstone, shale
		Thermopolis Sh.		shale
	Cedar Mountain Fm.		Burro Canyon Fm.	sandstone, shale
Jurassic		Morrison Fm.		sandstone, shale
	Curtis Fm.	Summerville Fm.		shale, limestone
		Entrada Ss.		sandstone
	Twin Creek Ls.	Carmel Fm.		limestone, shale
	Nugget Ss.			sandstone
Triassic-Jurassic		Navajo Ss.		sandstone
Triassic		Chinle Fm.		shale, sandstone
		Shinarump Mbr.		sandstone, conglomerate
	Thaynes Ls.	Woodside Sh.	Moenkopi Fm.	limestone, shale, sandstone
Paleozoic				
Permian	Park City Fm.	Phosphoria Fm.	State Bridge Fm.	limestone, shale
	White Rim Fm.		Garo Ss.	sandstone
Penn.-Permian	Weber Ss.		Maroon Fm.	sandstone, shale
			Eagle Valley Fm.	evaporites
Pennsylvanian	Morgan Fm.	Minturn Fm.	Gothic Fm.	sandstone, shale, limestone
	Round Valley Ls.	Belden Sh.		limestone, shale
		Molas Fm.		shale

P-540, UINTA-PICEANCE BASINS, PARK BASINS AND EAGLE BASIN
Generalized Stratigraphic Section (continued)

AGE	FORMATION			GENERAL LITHOLOGY
	West		East	
Mississippian	Doughnut Fm.		Manning Cyn. Fm.	shale
	Humbug Fm.			sandstone
	Deseret Ls.		Leadville Ls.	limestone
	Gardison Ls.	Madison Ls.		limestone
Devonian - Miss.		Chaffee Group		sandstone, dolomite
		Gilman Ss.		sandstone
		Dyer Dolo.		dolomite
		Parting Fm.		sandstone
Ordovician		Fremont Ls.		limestone, dolomite
		Harding Ss.		sandstone
		Manitou Fm.		limestone
Cambrian		Doterso Fm. - Peerless Fm.		limestone
	Lodore Ss.		Sawatch Quartzite	sandstone
	Maxfield Ls.			limestone
	Ophir Fm.			shale
	Tintic Quartztite			sandstone

P-555, SAN JUAN BASIN
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas producing units in the San Juan basin. They represent only a sampling of the production for which data are available. Since most of the production occurs on a basin-wide basis, rather than from distinct fields, the following information is reported by formation, rather than by field. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Unit or Formation	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Mesaverde Formation	6,923,545	7,756,125
Dakota Group	4,266,730	4,676,480
Pictured Cliffs Sandstone	2,932,510	1,807,661
Chacra Sandstone	148,965	270,443
Fruitland Formation	92,036	91,907

The Uinta basin is the largest and most highly productive portion of the province. It is bounded on the north by the Uinta Mountains, on the west by the Wasatch Range, on the south by the San Rafael swell and Uncompahgre uplift, and on the east by the Douglas Creek arch. The axis of this asymmetric, east-west trending basin lies in the northern portion of the basin. Sediments are more than 30,000 feet deep in this region; more than 11,000 feet of which are Tertiary continental and lacustrine deposits. Major downwarping of the basin occurred during late Cretaceous and Eocene.

The Piceance basin is the second largest and second most productive portion of the province. It is bounded on the west by the Douglas Creek arch, on the north by the Axial Basin anticline, on the east by the White River uplift and on the southwest by the Uncompahgre uplift. Up to 27,000 feet of sedimentary rocks were deposited in the deepest portion of the basin. Most fields in this region produce from more than one interval; some have up to six reservoirs. Rangely field, which lies on the Douglas Creek arch, is the only giant oil and gas field in Colorado.

Eagle and North Park basins continue to be areas of exploration interest. Small amounts of both oil and gas are produced in these basins. South Park and Middle Park contain no production at this time. South Park has some potential for production. Middle Park has very little potential.

Reservoir rocks. The Eocene Green River and Wasatch Formations are the primary reservoirs in the Uinta basin. They are also important units in the Piceance basin. In the Park basins, some production is from the Paleocene Coalmont Formation. Cretaceous reservoirs in this province are the Mesaverde, Frontier, Codell, Dakota, Muddy and Lakota sandstones. Some fields produce from fractured Pierre and Niobrara intervals. Jurassic sandstone reservoirs are the Morrison and Entrada Formations. Productive Paleozoic units are the Permian Phosphoria Formation and the Pennsylvanian-Permian Weber Sandstone. Surface sands are mined in part of the Uinta basin, as well as solid hyrocarbons (gilsonite).

Traps. Stratigraphic traps are very important in this province. Present production from stratigraphic traps is confined to Cretaceous and Paleocene rocks. Types of stratigraphic traps include deltaic lenses, channel and bar sands, permeability pinchouts and asphalt seals. Traditional structural traps in the province are fault traps, anticlines and faulted anticlines. These affect all stratigraphic intervals. Unconformity surfaces form traps in the Weber and Phosphoria Formations.

Potential source rocks. Source rocks in the Uinta, Piceance and Eagle basins range in age from Mississippian to Eocene. All are mature in certain areas. These units are the Eocene Wasatch and Green River; Upper Cretaceous Mesaverde Group and Mancos Shale; Pennsylvanian Phosphoria; Mississippian Manning Canyon Shale and Deseret Limestone. Possible source rocks for the Park basins are all Cretaceous in age. They are the Niobrara, Greenhorn, Mowry and Thermopolis Formations.

P-545, SAN JUAN MOUNTAINS, SAN LUIS BASIN, LAS VEGAS-RATON BASIN, SIERRA GRANDE UPLIFT

This region of southern Colorado and northeastern New Mexico contains two structural basins, two structural arches and two mountain ranges. Present production is restricted to minor amounts of non-associated gas which is scattered through the province. Most of the production is located in the northern part of the Las Vegas-Raton basin. Two fields are located on the Apishapa uplift and one field lies at the southern nose of the Uncompaghre Mountains in Ouray County, Colorado. The Las Vegas-Raton basin contains over 7,200 feet of sediments ranging in age from Devonian to Holocene. The San Luis basin is considered a northern extension of the Rio Grande Rift and is cross-cut by numerous fault blocks. Total sediment thickness, which may exceed 20,000 feet, varies greatly over these blocks. Much of the San Luis basin and the Sierra Grande arch are covered with volcanics.

Reservoir rocks. Potential reservoir rocks range in age from Pennsylvanian to Paleocene. They include the Cretaceous-Paleocene Raton Formation; the Upper Cretaceous Vermejo Formation, Trinidad Sandstone, fractured Niobrara Formation, Codell Sandstone Dakota equivalents; the Jurassic Entrada Sandstone; the Permian Glorieta Sandstone; the Pennsylvanian-Permian Sangre de Cristo Formation;

P-545, SAN JUAN MOUNTAINS, SAN LUIS BASIN, LAS VEGAS-RATON BASIN AND SIERRA GRANDE UPLIFT

Generalized Stratigraphic Section

AGE	FORMATION			GENERAL LITHOLOGY
	West		East	
Cenozoic				
Oligocene			Farisita Congl.	conglomerate
Eocene			Huerfano Fm.	shale, sandstone
			Cuchara Fm.	sandstone, shale
Paleocene	Animas Fm.		Poison Canyon Fm.	arkose, sandstone
Late Cret.-Paleocene			Raton Fm.	sandstone, shale, coal
Mesozoic				
Late Cretaceous	Kirkland Sh.			shale, sandstone
	Fruitland Fm.		Vermejo Fm.	shale, sandstone, coal
	Pictured Cliffs Ss.		Trinidad Ss.	sandstone
	Lewis Sh.		Pierre Shale	shale
	Mesaverde Gp.		Colorado Gp.	shale, sandstone, limestone
	Mancos Sh.		Niobrara Fm.	marl, shale, limestone
			Benton Gp.	
			Carlile Shale	shale, sandstone
			Codell Ss. Mbr.	sandstone
			Greenhorn Ls.	limestone, shale
			Graneros Sh.	shale
Early Cretaceous		Dakota Ss.		sandstone, shale
	Burro Canyon Fm.		Purgatoire Fm.	sandstone, shale
Jurassic		Morrison Fm.		shale, sandstone
	Ralston Creek Fm.		Exeter Ss.	limestone, sandstone
	Wanakah Fm.			sandstone
		Entrada Ss.		sandstone
Triassic		Johnson Gap Fm.		limestone
		Dockum Gp.		shale, sandstone
			Sheep Pen Ss.	sandstone
	Chinle Fm.		Sloan Canyon Fm.	shale, sandstone
	Dolores Fm.	Santa Rosa Ss.	Travessor Fm.	sandstone, shale
			Baldy Hill Fm.	shale
Paleozoic				
Permian	Bernal Fm.		Whitehorse Fm.	sandstone
	Cutler Fm.	San Andres Ls.		limestone
		Glorieta ("Lyons") Ss.		sandstone
		Yeso Fm.		shale, sandstone
Penn.-Permian	Abo Fm.	Sangre de Cristo Fm.		arkose, sandstone, shale
Pennsylvanian	Rico Fm.			sandstone
	Magdalena Gp.		Hermosa Fm.	limestone, shale
	Madera Fm.			limestone
	Sandia Fm.			shale
Mississippian	Meramac Gp.	Terrero Fm.	Leadville Ls.	limestone, shale, sandstone
		Espiritu Santu Fm.		limestone

and the Pennsylvanian Madera Limestone. Carbon dioxide is produced from Jurassic sandstones and Pennsylvanian-Permian arkoses in Harding County, New Mexico. Helium, nitrogen and carbon dioxide are produced from the Permian at the Model Dome field on the Apishapa uplift.

Traps. Stratigraphic traps may be found in most intervals. These include sandstone lenses and porosity pinchouts. Structural traps include anticlines, faulted anticlines and reverse faults. Combinations of these traps may exist.

Potential source rocks. The most likely source rocks in the province are the Raton and Vermejo Formations and Colorado Group. Paleozoic carbonate rocks may also be source beds in parts of the province.

P-550, PARADOX BASIN

This province covers most of southeastern Utah and part of southwestern Colorado. It contains three major producing regions: the Paradox basin, the Uncompahgre uplift and the San Rafael Swell.

The Paradox basin is a sedimentary basin containing more than 24,000 feet of sedimentary rocks in its deepest portion. These rocks range in age from Cambrian to Tertiary. The basin is bounded on the west and southwest by the San Rafael Swell and the Monument uplift, on the southeast by the Four Corners Plateau, and on the east and northeast by the Uncompahgre uplift. Major downwarping of the basin occurred during the Pennsylvanian and Permian Periods. Production is presently confined to the southeast corner of San Juan County, Utah, and to northern San Juan and southern Grand Counties, Utah. Carbon dioxide and helium are also produced in the province.

Reservoir rocks. Major production in the Paradox basin is from the Pennsylvanian Hermosa, Callville and Paradox Formations; the Mississippian Leadville Formation; and the Devonian Aneth Formation. Production from the Uncompahgre uplift is mostly from the Cretaceous Dakota Sandstone, fractured Mancos Shale, Cedar Mountain Sandstone, and Castlegate Member of the Mesaverde Formation; from the Jurassic Salt Wash Member of the Morrison Formation and Entrada Sandstone; and from the Permian Coconino Sandstone. On the San Rafael Swell, production has been from the Upper Cretaceous Ferron Member of the Mancos Shale, the Jurassic Navajo Sandstone and the Triassic Moenkopi Limestone. Other reservoir rocks in the province include the Triassic Sinbad Limestone and Timpoweap Limestone, the Permian Kaibab Limestone and White Rim Sandstone, and the Devonian McCracken Sandstone.

Traps. Stratigraphic traps are common in the Paradox basin. These include biohermal limestone mounds and porosity changes, and are more common in the southern portion of the basin. Salt anticlines and faulted anticlines are more common in the northern part of the basin. Pre-salt fault blocks are a major trapping mechanism. On the Uncompahgre uplift and San Rafael Swell, anticlines and porosity pinchouts are trapping mechanism.

Source rocks. The source of hydrocarbons appears to be mostly from Pennsylvanian-age rocks, especially the black shales interbedded with salt in the Paradox and Hermosa Formations. The Cretaceous Mancos Shale and Frontier Formation are the probable source beds for much of the Mesozoic production.

Future exploration. This province is in an early stage of exploration. Other reservoir intervals in addition to the Pennsylvanian rocks need to be examined in the Paradox basin, especially the Ferron Sandstone Member of the Mancos Shale, and the Glen Canyon Group, the White Rim Sandstone, Kaibab and Coconino Formations. There are probably more salt anticlines and algal mounds as well as other structural traps and updip pinchouts to be discovered. Possible traps also lie beneath laccolithic intrusions in the region.

P-550, PARADOX BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Mesozoic		
Cretaceous		
Late	Mesaverde Gp.	sandstone and shale
	Mancos Sh.	shale
	Greenhorn Ls. Mbr.	limestone
	Graneros Sh. Mbr.	shale
	Dakota Ss.	sandstone
Early	Burro Canyon Fm.	sandstone
Jurassic	Morrison Fm.	shale and sandstone
	San Rafael Gp.	
	Bluff Ss.–Junction Creek Ss.	sandstone
	Summerville Fm.	shale and sandstone
	Curtis Fm.	shale
	Entrada Fm.	sandstone
	Carmel Fm.	shale
	Glen Canyon Gp.	
	Navajo Fm.	sandstone
	Kayenta Fm.	red beds
Triassic	Wingate Fm.	sandstone
	Chinle Fm.	red beds
	Church Rock Mbr.	
	Owl Rocky Mbr.	
	Petrified Forest Mbr.	
	Moss Back Mbr.	
	Monitor Butte Mbr.	
	Temple Mtn. Mbr.–Shinarump Mbr.	conglomerate
	Moenkopi Fm.	red beds
Paleozoic		
Permian	Cutler Fm.	arkoses
	White Rim Ss.--DeChelly Ss.	sandstone
	Organ Rock Tongue	
	Cedar Mesa Ss. Mbr.	sandstone
	Halgaito Tongue–Elephant Cyn. Fm.	
Pennsylvanian	Hermosa Gp.	
	Honaker Trail Fm.	limestone and sandstone
	Paradox Fm.	evaporites
	Pinkerton Trail Fm.	limestone
	Molas Fm.	red shale
Mississippian	Leadville Fm.	dolomite and limestone
Devonian	Ouray Fm.	dolomite
	Elbert Fm.	dolomite and shale
	McCracken Ss. Mbr.	
	Aneth Fm.	shale and limestone
Silurian	missing	
Ordovician	missing	
Cambrian	Lynch Dolo.	dolomite
	Muav Ls.	limestone
	Bright Angel Sh.--Ophir Sh.	shale
	Ignacio Quartzite	quartzite

P-555, SAN JUAN BASIN

The San Juan basin is one of the major gas provinces of the United States. It is bounded on the south by the Zuni uplift, on the east by the Defiance uplift, on the north by the San Juan uplift and on the east by the Nacimiento uplift. This structural basin covers 15,000 to 20,000 square miles and contains up to 15,000 feet of sedimentary rocks.

Reservoir rocks. Production in the basin is mostly from Cretaceous sandstones. Upper Cretaceous reservoir rocks include the Pictured Cliffs Sandstone, the Fruitland Formation, the Chacra Sandstone, the Mesaverde Group (Cliff House and Point Lookout Members) and the Gallup Sandstone. With fracturing, some oil has been produced from the Mancos Shale. The Dakota Group is the dominant Lower Cretaceous reservoir in the basin. There is limited production from the Jurassic Entrada Sandstone and Morrison Formation. The Pennsylvanian Hermosa Formation produces oil, natural gas and helium along the western flank of the basin. Helium is found in the Devonian Ouray Limestone.

Traps. Stratigraphic trapping dominates in the basin. The specific trapping conditions include sandstone lenses, channels and bars and are influenced by differential compaction related to ancient topographic highs. The sedimentary rocks in the area are largely underpressured. Hydrodynamic traps have been recognized in the Gallup and Entrada Sandstones. Anticlinal traps are confined to the southwestern flank of the basin. Hydrodynamic conditions and low permeability of reservoir rocks are the main trapping mechanisms which have resulted in the formation of one giant gas field in the Cretaceous rocks of the central portion of the basin.

Potential source rocks. The Upper Cretaceous Mancos Shale and the Menefee Member of the Mesaverde Formation are the most likely sources for hydrocarbons found in the Upper Cretaceous reservoirs. The upper Jurassic Todilto Formation may have been a source bed for the Dakota Group and for the Entrada Sandstone. The Hermosa Formation is another likely source bed.

Producing trends. The Hogback monocline on the northwestern flank of the basin is a striking structural feature with several producing fields. Anticlines are confined to the rims of the basin and no folding has been detected in the central portion of the basin. The central portion is basically one giant gas field with a diameter of 100 miles and covering an area of over one million acres. Fracturing in the Dakota Group has produced the Basin Dakota field, in which production occurs at depths shallower than 8,000 feet. Production in the Pictured Cliffs Sandstone is from elongate, northwest-trending sandstone stringers encased in shales.

Future exploration. Potential reservoir rocks lie below the Dakota Group; the Pennsylvanian section is especially promising. Jurassic reservoirs should be examined further also. There is room for expansion of the Basin Dakota field into Sandoval County. The southern and eastern flanks of the basin warrant further exploration.

P-560, SOUTHERN BASIN AND RANGE PROVINCE

This province covers southern Arizona and southwestern New Mexico. Production of natural gas or oil has been established in Otero County, New Mexico but is currently shut in. Carbon dioxide has been produced from the Estancia field in Torrance County, New Mexico. This area is considered a frontier region for petroleum exploration whose potential has not yet been determined.

Southern Arizona is a region of Precambrian rocks, lava flows and alluvial sediments. It has been postulated that the Western Thrust Belt extends from southernmost Nevada across southern Arizona, but this has not been confirmed by the results of limited drilling. If the Thrust Belt does exist in this region, then the potential for future production would be greatly increased. Additionally, discoveries of natural gas in Mexico, south of southwestern Arizona, raise some possibility for the establishment of production in westernmost Arizona. The Pedregosa basin of southeastern Arizona and southwestern New Mexico contains over 14,500 feet of sedimentary rocks and, thus, has some potential for production.

Central and southern New Mexico contains five sedimentary basins and the Lucero shelf. Sedimentary rocks representing all periods of the Paleozoic Era are present together with Jurassic and Cretaceous sedimentary rocks. Central New Mexico contains a thick Miocene-Pliocene sequence of continental

P-555, SAN JUAN BASIN
Generalized Stratigraphic Section

AGE	FORMATION		GENERAL LITHOLOGY
	West	East	
Mesozoic			
Cretaceous			
Late	Kirtland Sh.		shale
	Farmington Ss. Mbr.		sandstone
	Fruitland Fm.		shale, sandstone, coal
	Pictured Cliffs Ss.		sandstone
	Lewis Sh.		shale
	Mesaverde Gp.		
	Cliff House Ss.	Chacra Ss.	sandstone
	Menefee Fm.		shale, sandstone, coal
	Point Lookout Ss.		sandstone
	Mancos Sh.		shale
	Dakota Ss.		sandstone
Early	Burro Canyon Fm.		sandstone and shale
Jurassic	Morrison Fm.		shale and sandstone
	Bluff Ss.		sandstone
	Summerville Fm.		shale and sandstone
	Todilto Ls.		limestone and evaporites
	Entrada Ss.		sandstone
	Carmel Sh.		shale
	Navajo Ss.		sandstone
	Kayenta Fm.		red beds
Triassic	Wingate Ss.		sandstone
	Chinle Fm.		red beds
	Shinarump Congl.		conglomerate
	Moenkopi Fm.		red beds
Paleozoic			
Permian	DeChelly Ss.	San Andres Ls.	sandstone, limestone
	Cutler Fm.	Glorieta Ss.	sandstone
	(arkoses)	Yeso Fm.	shale, dolomite, sandstone
		Abo Fm.	red beds
Pennsylvanian	Hermosa Fm.	Madera Ls.	limestone
	Molas Fm.	Sandia Fm.	shale
Mississippian	Leadville Ls.		limestone and dolomite
Devonian	Ouray Ls.		dolomite
	McCracken Ss.		sandstone
	Aneth Fm.		shale and limestone
Silurian	missing		
Ordovician	missing		
Cambrian	Ignacio Quartzite		quartzite

P-560, SOUTHERN BASIN AND RANGE PROVINCE
Generalized Stratigraphic Section

AGE	FORMATION AND LITHOLOGY		
	CENTRAL NM	SOUTHERN NM	SOUTHERN AZ
Cenozoic			
Miocene-Pleistocene	Santa Fe Gp.-ss,cong		
Eocene	Galisteo Fm.-ss,sh		
Mesozoic			
Cretaceous			
Late	Mesaverde Fm.-ss,sh	Gallup Ss.-ss	Ft. Crittenden Fm.-cong
	Mancos Sh.-sh		Colorado Fm.-ss
			Beartooth Fm.-ss
Early	Dakota-Sarten Ss.-ss		Bisbee Gp.-sh,ss,ls
			Mojada Fm.-ss
			Mural Fm.-ls
Jurassic	Todilto Fm.-ls,sh		
	Entrada Ss.-ss		
			"Canelo Hill Vol."-ss
			Gardner Canyon Fm.-sh
Triassic	Dockum Gp.-sh,ss		
	Chinle Fm.-sh		
	Santa Rosa Ss.-ss		
Paleozoic			
Permian	Bernal Fm.-sh		Naco Gp.-ls,ss,sh
	San Andres Fm.-ls		Rainvalley Fm.-ls
	Glorieta Ss.-ss		Concha Ls.-ls
	Yeso Fm.-sh,ls,ss		Scherrer Fm.-ss
			Epitaph Dolo.-dolo
Penn.-Perm.	Sangre de Cristo-Abo Fm.-ss,sh,arkose		Colina Ls-ls
		Hueco-Bursum Fm.-ls	Earp Fm.-sh
Pennsylvanian	Magdalena Gp.- Hermosa Fm.-	Panther Seep Fm.-ls,sh	Horquilla Ls.-ls
	Madera Fm.-ls	Lead Camp Ls.-ls	
	Gray Mesa Mbr.-ls		
	Sandia Fm.-sh		
			Black Prince Ls-ls
Missisippian		Helms Fm.-sh	
	Tererro Fm.-ls	Rancheria Fm.-ls	Paradise Fm.-ls
	Espirito Santo Fm.-ls	Lake Valley Fm.-ls	Escabrosa Gp.-ls
Devonian	Caballero Fm.-ls		
	"Percha" Sh-sh	Martin Fm.-ls	
	Sly Gap Fm.-sh		
	Oñate Fm.-sh		
Silurian	Fusselman Dolo.-dolo		Fusselman Dolo.-dolo
Ord.- Silurian	Valmont Dolo.-dolo		
Ordovician	Montoya Fm.-ls		Montoya Fm.-ls
	El Paso Fm.-ls		El Paso Fm.-ls
Cambro-Ordovician	Bliss Fm.-ss		Bliss Fm.-ss
			Abrigo Fm.-sh
			Bolsa Quartzite-ss

sedimentary rocks and volcanics. The Tularosa (Orogrande) and Jornada del Muerto basins contain over 7,000 feet of sedimentary rocks. The Tularosa basin contains prospective Pennsylvanian biohermal limestones.

Reservoir rocks. Potential reservoir rocks in central New Mexico include the Cretaceous Dakota Formation and Gallup Sandstone; the Jurassic Entrada Sandstone; the Permian Glorieta Sandstone and San Andres Limestone; the Pennsylvanian-Permian Sangre de Cristo Formation; and the Pennsylvanian Hermosa Formation and Madera Limestone. South-central New Mexico reservoirs include the Pennsylvanian Magdalena Group; the Mississippian Lake Valley Formation; the Silurian Fusselman Formation; and the Ordovician El Paso and Montoya Formations as well as from undifferentiated Cretaceous, Permian and Pennsylvanian rocks. Potential reservoirs in the Pedregosa basin range in age from Cambrian to Early Cretaceous and include the Lower Cretaceous Mojado and the upper Bisbee Group; the Permian Colina, Epitaph, Concha and Rainvalley Formations; the Pennsylvanian Horquilla and Earp Formations; the Mississippian Paradise and Escabrosa Formations; the Devonian Martin Formation; the Silurian Fusselman Formation; the Ordovician El Paso and Montoya formations; and the Cambro-Ordovician Bliss Sandstone and Abrigo Formation.

Traps. Potential traps are both structural and stratigraphic. Anticlinal and faulted anticlinal traps are present. Stratigraphic traps include bioherms, sandstone channels and lenses, carbonate-evaporite sequences and carbonate-red bed sequences. Thrust faulting, shear zones and block faulting form potential traps in southern Arizona.

Potential source rocks. Potential source rocks in central New Mexico are the Cretaceous Mancos Shale and Colorado Group, Jurassic Todilto Limestone, Permian San Andres Limestone, and Pennsylvanian Madera Formation. In south-central New Mexico, the prospective source rocks are the Cretaceous Mancos Shale, Permian Hueco-Colina Formations, Pennsylvanian Gray Mesa Formation, Mississippian Lake Valley-Escabrosa Limestone and Devonian Percha Formation. In southern Arizona and southwestern New Mexico possible source rocks include the Permian Colina, Epitaph, Concha, Scherrer, and Rainvalley Formations; Pennsylvanian Horquilla Formation; Mississippian Paradise Formation; and Devonian Percha Formation.

P-565, PLATEAU PROVINCE AND BLACK MESA BASIN

This province covers northern Arizona and part of southern Utah. The province includes the Colorado Plateau, the Black Mesa basin and the Defiance uplift. Production in the province is presently confined to the Defiance uplift. The Colorado Plateau consists of a thick series of sedimentary rocks which have undergone relatively little deformation since their deposition. The section does not contain favorable potential source rocks and there are relatively few potential traps so the Colorado Plateau has little or no potential for future natural gas production. The Black Mesa basin is a structural downwarp instead of a depositional sedimentary basin and also has little or no potential for future natural gas production.

Reservoir rocks. Current production comes from rocks ranging in age from Devonian to Cretaceous. The reservoir formations include Cretaceous sandstones; the Permian Coconino Sandstone; the Pennsylvanian Paradox and Naco Formations; the Mississippian Leadville Limestone; and the Devonian Aneth and McCracken Formations. All intervals produce both oil and natural gas. Helium is also produced from both the Coconino Sandstone and the Devonian reservoirs.

Traps. Biohermal limestones are common in the Aneth Formation. Variable porosity and permeability is a common stratigraphic trap. Both anticlines and faulted anticlines are prospective targets. Production has also been developed in units adjacent to a Tertiary sill.

Potential source rocks. The probable source beds for the province are carbonate rocks, including the Pennsylvanian Paradox and Naco Formations and the Devonian Aneth and Martin Formations.

Future exploration. Much of the province apparently has little potential for natural gas production. The Defiance uplift, however, has been sparsely explored and, undoubtedly, contains more stratigraphic traps. Mesozoic intervals have been largely ignored and contain potential reservoirs.

P-565, PLATEAU PROVINCE AND BLACK MESA BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Eocene	Chuska Ss.	sandstone
Paleocene	Cedar Breaks Fm.	shale, limestone
Mesozoic		
Late Cretaceous	Kaiparowits Fm. – Mesaverde Gp.	sandstone, shale, coal
	Wahweap Fm.	sandstone, shale, siltstone
	Straight Cliffs Ss.- Tropic Sh. – Mancos Sh.	sandstone, shale
Early-Late Cretaceous	Dakota Fm.	sandstone, shale
Jurassic	Morrison Fm.	shale, sandstone
	San Rafael Gp.	limestone, sandstone, shale
	Cow Springs Ss.	sandstone
	Entrada Ss.	sandstone
	Carmel Fm.	limestone
Triassic-Jurassic	Glen Canyon Gp.	sandstone, shale
	Navajo Ss.	sandstone
	Kayenta Fm.	sandstone
	Moenave Fm.	sandstone
	Wingate Ss.	sandstone
Triassic	Chinle Fm.	shale, siltstone, sandstone
	Church Rock Mbr.	shale and siltstone
	Owl Rocky Mbr.	shale and siltstone
	Petrified Forest Mbr.	shale and siltstone
	Monitor Butte Mbr.	shale and siltstone
	Shinarump Mbr.	sandstone
	Moenkopi Fm.	siltstone, sandstone
Paleozoic		
Permian	Kaibab Ls. – Hoskinnini Sh.	limestone, evaporites, shale
	Cutler Gp.	
	White Rim Ss.	sandstone
	Toroweap Fm.	limestone
	Coconino Ss. – De Chelly Ss.	sandstone
	Organ Rock Sh.	shale
	Cedar Mesa Ss.	sandstone
	Elephant Canyon Fm.–Halgaito Sh.	shale
	Hermit Sh.	shale
	Esplanade Ss.	sandstone
Pennsylvanian-Permian	Supai Gp.	sandstone, shale
Pennsylvanian	Hermosa Gp. –Naco Gp.	limestone, dolomite, evap.
	Honaker Trail Fm.	sandstone and limestone
	Paradox Fm.	limestone, evaporites
	Pinkerton Trail Fm.	limestone and shale
	Molas Fm.	shale

P-565, PLATEAU PROVINCE AND BLACK MESA BASIN
Generalized Stratigraphic Section (continued)

AGE	FORMATION	GENERAL LITHOLOGY
Mississippian	Redwall Ls. – Leadville Ls.	limestone
Devonian	Temple Butte Ls. – Ouray Fm.	limestone
	Martin Fm. – Elbert Fm. – Aneth Fm.	limestone, sandstone
	McCracken Mbr.	sandstone
Cambrian	Lynch Dolo.	dolomite
	Tonto Gp.	limestone, sandstone, shale
	Muav Ls.	limestone
	Bright Angel Sh.	shale
	Tapeats Ss.	sandstone
Precambrian	Grand Canyon Supergroup	sandstone, limestone, shale

P-570, SWEETGRASS ARCH AND CENTRAL MONTANA
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Sweetgrass arch and Central Montana province. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Tiger Ridge area	145,000	109,000
Cut Bank	482,379	75,271
East Keith	50,180	17,988
Bullwhacker	8,885	13,262
Kevin Sunburst	73,152	12,107
Sherard	15,700	10,287
Whitlash	36,745	5,051
Big Coulee	27,154	4,601
Ethridge	3,285	4,502
Utopia	20,348	4,224
Lake Basin North	9,494	1,727

P-570, SWEETGRASS ARCH AND CENTRAL MONTANA
Generalized Stratigraphic Section

AGE	FORMATION AND LITHOLOGY		
	Sweetgrass Arch		Central Montana
Cenozoic			
Paleocene-Eocene			Wasatch Fm.-ss, sh
Paleocene	"Willow Creek"-sh		Fort Union Fm.-ss, sh
Mesozoic			
Cretaceous			
Late	St. Mary River Fm.-sh		Hell Creek Fm.-ss
	Horsethief Ss. -ss		Fox Hills Ss.-ss
		Bearpaw Sh.-sh	
	Two Medicine Fm.-ss		Judith River Fm.-ss
			Claggett Sh.-sh
			Eagle Ss.-Gammon Sh.-ss, sh
			Virgelle Ss.-ss
			Telegraph Creek Fm.-ss, sh
		Marias River Fm.-sh, ls	
Early		Blackleaf Fm.-ss, sh	
		Bow Island (Viking) Ss.-ss	
	Inyan Kara Gp.-ss,sh		Kootenai Fm.-ss
	Moulton Ss. – Sunburst Ss.-ss		Lakota Ss. Mbr.-ss
	Lander Ss.-.ss		
	Cutbank Ss.-ss		
Jurassic		Morrison Fm.-sh, ss	
	Ellis Group-ss, ls,sh		
	Swift Fm.-ss		Swift Fm.-ss
	Reirdon Fm.-ls,sh		Reirdon Fm.-ls, sh
	Sawtooth Fm.-sh		Piper Fm.-sh, ss, ls
Paleozoic			
Pennsylvanian			Tensleep Fm.-ss
			Amsden Fm.-ls, ss
			Tyler Fm.-sh
Mississippian		Big Snowy Gp.-sh, ss	
		Heath Fm.-sh	
		Madison Gp.-ls	
		Charles Fm.-ls	
		Mission Canyon Fm.-ls	
		Lodgepole Ls.-ls	
		Cottonwood Canyon Mbr.-ls	
Devonian-Mississippian		Bakken Sh.-sh	
Devonian		Three Forks Fm.-sh	
		Jefferson Gp.-ls	
		Birdbear (Nisku) Fm.-ls	
		Duperow Fm.-ls	
		Souris River Fm.-ls	
Ordovician	Red River Fm.-ls		Bighorn Dolo.-dolo
Cambrian		Emerson Fm.-sh	Grove Creek Fm.-Deadwood Fm.
	Switchback Sh.-sh	Pentagon Sh.-sh	Park Sh.-sh
	Steamboat-Pagoda Ls.-ls		Meagher Ls.-ls
	Damnation Ls. – Dearborn Fm.-ls		Wolsey Sh.-sh
	Gordon Sh.-sh		
		Flathead Ss.-ss	

P-570, SWEETGRASS ARCH AND CENTRAL MONTANA

This region covers the central portion of Montana. It contains a thick series of sedimentary rocks of Mesozoic and Paleozoic age, including both clastic and carbonate rocks. Numerous domes, arches, and young intrusive mountain complexes dot the province. Both associated/dissolved and non-associated gas are produced in this region.

Reservoir rocks. Numerous sandstone reservoir rocks of Cretaceous age include the Judith River and Eagle Members of the Pierre Shale, the Bow Island Member of the Blackleaf Formation, Frontier Formation, Cat Creek, Viking, Moulton, Sunburst, Lakota, and Cutbank Sandstones. On the Sweetgrass arch, the Jurassic Swift and Sawtooth Formations of the Ellis Group are productive. Paleozoic units of interest are the Pennsylvanian Amsden Group and Tyler Formation; Mississippian Madison Group; and Devonian Nisku (Birdbear) Formation.

Traps. Anticlines and domes form traps for all stratigraphic intervals throughout the region. Faults are numerous due to various tectonic events in the area and provide traps for many units. In all Cretaceous units and in the Tyler, sandstone channels and lenses are the major trapping style. Porosity variations occur in all intervals. In the Madison, buried topographic traps can be found. At various intervals, angular unconformities are the trapping mechanism. Hydrodynamic tilting of oil/water and gas/water contacts occurs in the south-central portion of the province.

Potential source rocks. Many Jurassic and Cretaceous units are potential source rocks. These are the Montana Group, Colorado Group, Inyan Kara Group, and Rierdon Formation. Paleozoic sources are probably the Tyler; Mississippian Heath and Lodgepole Formations; and Devonian-Mississippian Cottonwood Canyon and Bakken Formations.

P-575, MONTANA FOLDED BELT

This region includes the northern projection of the Wyoming-Utah-Idaho Thrust belt. The present day configuration of the region was formed during the Laramide Orogeny in late Cretaceous and early Tertiary time. This deformation involving both Paleozoic and Mesozoic rocks, proceeded from west to east and progressively older sediments are involved to the west where more faulting has occurred. Major thrust faults, and imbricating minor thrusts, form a series of complexly folded and faulted thrust packages. Folding is common in all intervals. In various portions of the province, several older, northeast-trending, fault blocks affect the thickness of sediments.

Southwestern Montana underwent deformation of a different nature starting with major vulcanism during Campanian time. This was followed by emplacement of the Boulder batholith in latest Cretaceous time. The western portion of the province is covered by mountain belts.

Potential reservoir rocks. The Mississippian Madison Group is presently the only productive interval in this region. Other prospective units are Paleocene sandstones; the Cretaceous Fox Hills Sandstone, Eagle Sandstone Member of the Pierre Shale, Cloverly Formation, Cat Creek Sandstone, Lakota Formation, and Cutbank Sandstone Member of the Kootenai Formation. Possible Paleozoic reservoirs are the Pennsylvanian Quadrant Formation and Shedhorn Sandstone; and the Devonian Three Forks and Jefferson Formations.

Traps. Major trapping mechanisms in the area are formed by thrust faults, folds and faulted folds. Sandstone bars and channels may form traps in the Cretaceous and Tertiary units. Facies changes in Paleozoic carbonate rocks are a possible trapping mechanism.

Potential source rocks. Possible source rocks include Paleocene shales; the Cretaceous Montana and Colorado Groups; the Triassic Thaynes Formation; the Pennsylvanian Phosphoria Formation; and the Devonian-Mississippian Exshaw and Sappington Member of the Three Forks Formation.

P-575, MONTANA FOLDED BELT
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Paleocene-Late Cretaceous	Fort Union Fm.	sandstone, shale
Mesozoic		
Cretaceous		
Late	Montana Gp.	
	Willow Creek Fm.	shale
	Beaverhead Congl.	conglomerate
	St. Mary River Fm.	shale
	Fox Hills Fm.	sandstone
	Two Medicine Fm.-Pierre Sh.	shale, sandstone
	Virgelle Ss.-Eagle Ss.	sandstone
	Telegraph Creek Fm.	shale
	Colorado Gp.	
	Marias River Shale	shale
Early	Blackleaf Fm.	shale
	Vaughn Sh.-Mowry Sh.	shale
	Dunkleburg-Muddy Ss.	sandstone
	Taft Sh.-Thermopolis Sh.	shale
	Kootenai Fm.	sandstone, shale
	Lakota-Cloverly-Cutbank-Sunburst Ss.	sandstone
Jurassic	Morrison Fm.	shale, sandstone
	Ellis Gp.	
	Swift Fm.	sandstone
	Rierdon Fm.	limestone, shale
	Sawtooth Fm.	limestone, shale
Triassic	Thaynes Fm.	limestone
	Woodside Fm.	limestone
	Dinwoody Fm.	shale
Paleozoic		
Permian	Shedhorn Ss.	sandstone
	Phosphoria Fm.	shale
	Park City Fm.	limestone
Pennsylvanian	Quadrant Fm.	sandstone
	Amsden Fm.	limestone, sandstone
Mississippian	Big Snowy Gp.	limestone, shale, sandstone
	Madison Gp.	
	Sun River Dolo.	dolomite
	Mission Canyon Fm.	limestone
	Lodgepole Limestone	limestone
Devonian	Three Forks Fm.-Exshaw Fm.-Sappington Fm.	shale, limestone
	Jefferson Fm.	limestone
	Maywood Fm.	shale
	Beartooth Butte Fm.	shale
Ordovician	Bighorn Dolo.	dolomite
Cambrian	Red Lion-Snowy Range Fm.	limestone
	Devils Glen Dolo.-Hasmark Dolo.	dolomite
	Damnation Ls.-Fishtrap Dolo.-Wolsey Sh.	limestone, dolomite, shale
	Gordon Sh.-Silver Hill Fm.	shale
	Flathead Ss.	sandstone

P-580, SNAKE RIVER BASIN

The Snake River downwarp is an arcuate basin whose borders lie on either side of the Snake River and roughly parallel the river. The basin lies between the overthrust fold belts of east-central and southeast Idaho and extends to the southwestern edge of Idaho, as far as, but not including, the Hells Canyon area.

The rock section is composed of numerous extrusive volcanic flows and air-fall material interbedded with fluvial and lacustrine clastic deposits which are more prominent in the southwestern area. Some black shales and a few coal beds are included in the section.

Numerous gas shows, ranging in quality from 750 to 1,400 Btu's per cubic foot have been found through seeps and in wells. Juvenile bitumens, apparently in place, have also been noted. Reservoir rocks and apparent source rocks have been identified. Trapping mechanisms pose a question. Drilling has been sparse to date and no commercial discoveries have been made, but there is continued industry interest spurred by shows. The potential for commercial natural gas accumulations is difficult to define. The exploration risk is high, but there are enough favorable indicators to hold out promise for the basin.

P-590, WYOMING-UTAH-IDAHO THRUST BELT

This area is made up of severely deformed Paleozoic and Mesozoic sediments, mostly of marine origin. Deformation occurred during the Laramide Orogeny in Cretaceous and early Tertiary time. The region is composed of a complex series of thrust sheets with anastomozing smaller thrust and later normal faults, making exploration difficult. Styles of deformation vary through the belt. In most areas the sediments are tightly folded as well as faulted. In other areas, Paleozoic rocks are severely faulted, whereas overlying Mesozoic sediments are both folded and faulted. The stacked sediment package is over 49,000 feet thick in the western portion of the province and 14,000 feet thick in the east. Production is presently confined to Wyoming and the area of Utah adjacent to the southwestern corner of Wyoming (Fossil basin). The Idaho portion of the province has produced shows and continues to be an exploration target. Oil, associated/dissolved gas, non-associated gas and condensate are produced. Non-associated gas from Paleozoic carbonate reservoirs is sour.

Reservoir rocks. Fourteen units ranging in age from Ordovician to Late Cretaceous are presently producing in this province. The Mississippian Madison Limestone, Triassic-Jurassic Nugget Sandstone and Pennsylvanian Weber Sandstone and Ordovician Bighorn Dolomite are major targets in this region. Other reservoirs include the Upper Cretaceous Frontier Formation; Jurassic Stump Sandstone and Twin Creek Limestone; Triassic Thaynes Limestone, Woodside Formation and Dinwoody Formation; Permian Phosphoria Formation; and Devonian Darby Formation.

Traps. Structural trapping affects all stratigraphic intervals. Structural traps are folded and thrusted anticlines. Potential stratigraphic traps include carbonate mounds in the Thaynes Limestone, changes in carbonate facies, and sandstone pinchouts.

Potential source rocks. The main source of hydrocarbons is Cretaceous marine sediments. Other possible sources include the Phosphoria, Thaynes, and Devonian Three Forks Formations.

P-575, MONTANA FOLDED BELT
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following is the estimate of cumulative production and remaining proved reserves for the only major gas field in the Montana folded belt for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Blackleaf Canyon	3,257	7,243

P-590, WYOMING–UTAH–IDAHO THRUST BELT
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major gas fields in the Wyoming-Utah-Idaho thrust belt. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Whitney Canyon-Carter Creek	153,270	609,379
Anschutz, East	7,091	641,510
Anschutz, West	1,983	573,200
Painter Reservoir	142,056	167,944
Session Mountain	890	5,352
Ryckman Creek	2,642	1,625
Yellow Creek	N/A	965

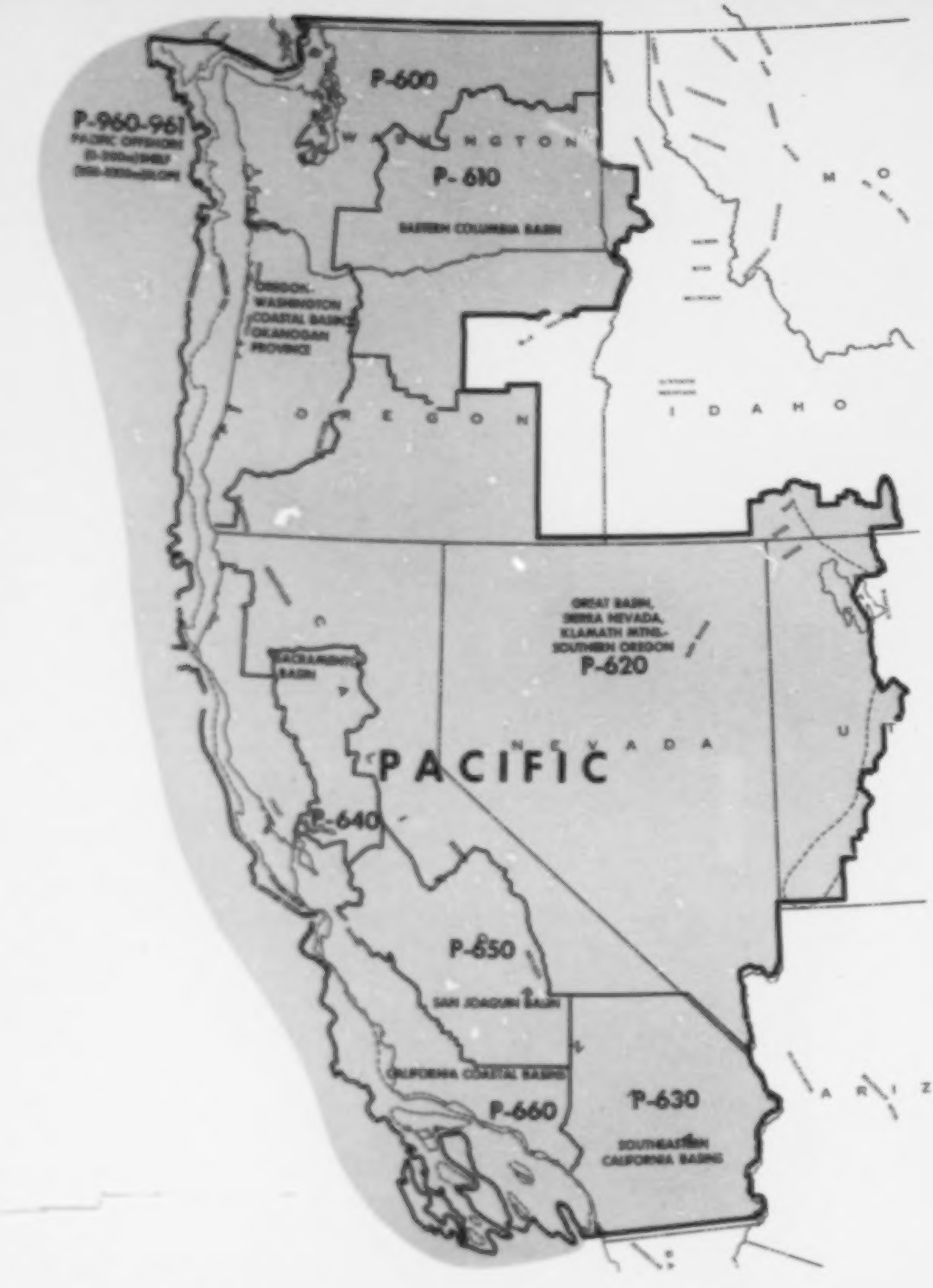
P-590, WYOMING–UTAH–IDAHO THRUST BELT
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Eocene-Pliocene	Fowkes Fm.	shale, sandstone
Eocene	Green River Fm.	shale
	Wasatch Fm.	shale, sandstone
Late Cretaceous-Paleocene	Evanston Fm.	sandstone, coal
Mesozoic		
Cretaceous		
Late	Adaville Fm.	sandstone, shale, coal
	Hilliard Fm.-Shurtliff Ss.	shale, sandstone
	Frontier Fm.	shale, sandstone, coal
Early	Aspen Sh.	shale, sandstone
	Bear River Fm.	shale, sandstone
	Gannett Gp.	shale, sandstone, conglomerate, limestone
Jurassic	Stump Ss.-Preuss Ss.	sandstone, evaporites, shale
	Twin Creek Ls.	limestone
	Gypsum Springs Fm.	shale, evaporites
Triassic-Jurassic	Nugget Ss.	sandstone
Triassic	Ankareh Fm.	shale, limestone, sandstone
	Thaynes Ls.	limestone
	Woodside Fm.	shale, marl
	Dinwoody Fm.	shale, limestone
Paleozoic		
Permian	Phosphoria Fm.	shale, limestone
Pennsylvanian	Wells Fm.-Weber Fm.	sandstone, limestone
	Morgan Fm.	limestone, sandstone, shale
Mississippian	Brazer–Madison Gp.	limestone
	Mission Canyon Ls. Mbr.	limestone
	Lodgepole Ls. Mbr.	limestone
Devonian	Darby Fm.-Three Forks Sh.-Jefferson Ls.	dolomite, shale, limestone, sandstone
Silurian		
Ordovician	Bighorn Dolo.-Leigh Dolo.	dolomite, limestone, sandstone
Cambrian	Gallatin Ls.	limestone, shale, dolomite
	Gros Ventre Fm.	shale, sandstone, limestone
	Flathead Ss.	sandstone

Table 15. Estimated resources of natural gas for provinces of the Rocky Mountain Area, December 1984 (billion cubic feet)

PROVINCE	ONSHORE	OFFSHORE	PROBABLE			POSSIBLE			SPECULATIVE		
	depth	water depth	Max.	M. likely	Min.	Max.	M. likely	Min.	Max.	M. likely	Min.
P-500, Williston basin	0-15,000'		1,500	1,000	300	600	500	500	800	600	400
	15-30,000'		500	200					*	*	*
P-510, Powder River basin	0-15,000'		1,500	1,100	700	2,500	2,000	1,300	800	600	400
	15-30,000'								2,300	1,200	600
P-515, Big Horn basin	0-15,000'		1,000	500	400	1,000	500	400	2,000	1,600	200
	15-30,000'		400	100	100	1,200	600	500	3,000	2,000	400
P-520, Wind River basin	0-15,000'		1,600	1,200	400	3,900	2,600	1,300	*	*	*
	15-30,000'		1,200	900	600	2,900	1,100	100	1,600	1,300	800
P-530, Greater Green	0-15,000'		9,275	5,895	3,068	11,390	7,330	3,800	3,500	1,200	300
River basin	15-30,000'		14,300	7,600	3,100	32,200	17,850	6,830	19,800	7,000	600
P-535, Denver basin, Chadron	0-15,000'		3,100	2,100	1,300	2,900	1,100	400	2,900	1,600	800
arch and Las Animas arch	15-30,000'								*	*	*
P-540, Uinta/Piceance basins,	0-15,000'		11,200	9,200	6,300	3,400	1,700	1,300	2,500	600	200
Park and Eagle basins	15-30,000'		400	200	100	1,300	900	200	2,300	800	200
P-545, San Juan Mountains,	0-15,000'					1,000	400	100	1,400	700	*
San Luis/Raton basins, etc.	15-30,000'								600	300	*
P-550, Paradox basin	0-15,000'		200	130	50	3,000	876	500	700	300	100
	15-30,000'								*	*	*
P-555, San Juan basin	0-15,000'		3,000	2,500	2,000	4,000	3,500	3,000	*	*	*
	15-30,000'								*	*	*
P-560, Southern Basin	0-15,000'					5,600	1,400	*	50	50	*
and Range province	15-30,000'								*	*	*
P-565, Plateau province,	0-15,000'		40	20	10	80	40	20	500	250	40
Black Mesa basin	15-30,000'								*	*	*
P-570, Sweetgrass arch and	0-15,000'		3,200	2,500	1,800	4,400	2,900	1,400	4,900	3,600	800
P-575, Montana Folded Belt	15-30,000'								*	*	*
P-580, Snake River basin	0-15,000'								300	200	100
	15-30,000'								*	*	*
P-590, Wyoming-Utah-Idaho	0-15,000'		9,400	4,800	3,400	7,000	3,700	1,500	15,000	7,000	2,500
Thrust Belt	15-30,000'		9,600	8,400	3,300	6,000	4,000	1,500	6,000	2,500	1,000
TOTAL, onshore	0-15,000'			30,945			28,546			18,300	
TOTAL, onshore	15-30,000'			17,400			24,450			15,100	
TOTAL, onshore, all depths				48,345			52,996			33,400	
GRAND TOTAL FOR AREA				48,345			52,996			33,400	

*Negligible quantity of natural gas estimated


P-960-961
PACIFIC OFFSHORE
(0-200m) SHELF
(200-2500m) SLOPE
P-600
WASHINGTON
P-610
EASTERN COLUMBIA BASIN
MO
OREGON-WASHINGTON COASTAL BASINS OKANOGAN PROVINCE
OREGON
IDAHO
GREAT BASIN, SIERRA NEVADA, KLAMATH MTNS.-SOUTHERN OREGON
P-620
SACRAMENTO BASIN
NEVADA
PACIFIC
UT
P-640
P-650
SAN JOAQUIN BASIN
CALIFORNIA COASTAL BASINS
P-660
P-630
SOUTHEASTERN CALIFORNIA BASINS
ARIZ

PACIFIC AREA

During the past two years, exploration activity within the San Joaquin Valley has continued at low to moderate levels. No new fields of significant size have been discovered. Drilling activity has been concentrated in three major trends:

1. The Stevens sands along the Bakersfield arch.
2. The Monterey Shale along the west side of the Valley.
3. The Temblor Formation surrounding the Tulare Lake Field.

The strongest exploratory pace continues along the Bakersfield arch in central Kern County. This has yielded many small extensions and one new field. Within the Monterey Shale, exploration has quickened during the latter half of 1984. New pool discoveries in the Asphalto and South Belridge Fields and continued exploration in the Lost Hills Field "Cahn Zone" are most significant. In the northern part of the San Joaquin Valley, exploratory drilling has been active since the discovery of Tulare Lake Field in 1982.

There was a decrease in the estimates for potential natural gas resources in all categories for the San Joaquin Valley. This is the result of a continuing re-evaluation by the Pacific Area Committee. Gas production in the Valley is predominantly associated/dissolved gas and the estimate of the potential gas resources has been brought into line with the potential oil discoveries.

In the Sacramento Valley, the estimate for Probable resources has been increased based on continued success in extending known fields. The decrease in the estimate for Possible resources largely reflects the gas discoveries of the past two years. The estimate for Speculative resources has been reduced due to the failure of deeper wells drilled since 1982 to find any significant gas production.

Significant exploration developments in the Sacramento Valley in 1983-84 include:

1. A discovery beneath the city of Stockton by Chevron.
2. East Brentwood Field, where several operators have made large volume wells from the Third Massive Sand beneath the shale-filled Megaros Canyon.
3. Continuing discoveries and extensions in the F Zone sands around Grimes, Tisdale and Sycamore Fields.
4. Deep Starkey Sand production at Denverton and West Rio Vista.

In the Coastal Basins, the Santa Maria basin has been the most active with several discoveries being made in the deep Monterey Shale. These have had high volumes of associated/dissolved gas with the oil production.

Drilling and seismic activity are currently at a relatively high level in Oregon. The only successful exploratory wells, however, have been the discovery of additional pools in the Mist Gas Field.

In Washington, deep drilling has occurred in Grant and Grays Harbor Counties. Shell and ARCO reached total depth of 17,518 feet in a Grant County well and have been testing the well. Gas production has been indicated, but the commerciality is still uncertain.

Drilling has been active in both Federal and California State offshore waters and has resulted in several discoveries. These include San Miguel, Point Pedernales, Bonito and Rocky Point, all in the offshore Santa Maria basin. Based on these results, the estimates for Probable and Possible resources have been increased. Estimates for resources in the Santa Barbara Channel area were also increased due to an announced deeper pool discovery at Molino Field.

P-600, OREGON-WASHINGTON COASTAL BASINS, OKANOGAN PROVINCE

This province presently has one productive field, Mist Field in Clatsop County, Oregon. Potential in the region is basically confined to the coastal region. The coastal region is composed largely of Tertiary rocks (both marine and continental) with some interbedded lava flows and is covered in places with glacial drift.

The Olympic Mountains are mostly a metamorphic complex with some lava flows. The Okanogan Highlands of northern Washington are a combination of intrusive and extrusive igneous rocks with metamorphosed regions. Historically there have been two other fields in the province: Ocean City and Bellingham. Ocean City in Grays Harbor County, Washington, produced approximately 12,500 barrels in four years from a fractured Oligocene sandstone. The Bellingham gas field in Whatcom County, Washington produced local amounts of Tertiary gas from sandstone lenses in glacial sediments.

Reservoir rocks. Present production is from the Eocene Cowlitz Formation. Potential reservoir rocks are the Miocene-Pliocene Quinault Formation, the Miocene Astoria Formation, the Miocene-Oligocene Yaquina Sandstone, and the Eocene Coaledo Formation.

Traps. The main trapping mechanism in the area is sandstone lenses. Unconformity truncations affect Pliocene and late Eocene rocks. Shale diapirs with accompanying onlaps and faults form potential traps in Miocene and Pliocene rocks.

Source rocks. Potential source rocks in this area are the Miocene Nye Shale, the Oligocene Alsea Formation and the Eocene Coaledo and Yamhill Formations.

P-610, EASTERN COLUMBIA BASIN

This province has very little natural gas potential. Most of the region is covered with thick plateau basalts. The Cascade Mountains, a series of volcanoes, are also included in this region. Historically there has been one gas field in this province, Rattlesnake Hills. Production was from vesicular basalts. The trap was a faulted anticline with thin shales acting as the seal. Total production was one billion cubic feet of gas. The source rock is unknown. There is some possibility of production from reservoir rocks and source rocks lying below the thinner portions of the lava flows.

P-620, GREAT BASIN, SIERRA NEVADA, KLAMATH MOUNTAINS AND SOUTHERN OREGON

This province has attracted a great deal of exploration attention recently. The region contains a thick paleozoic section with lesser amounts of Mesozoic and Tertiary rocks. The Great Basin is composed of numerous horst and graben blocks. The blocks are internally folded and faulted. This complicates the stratigraphy and makes exploration more difficult. Present hydrocarbon production is limited, but a new discovery has been recently made in Railroad Valley, Nevada. There is also limited production in the Klamath Mountains. The province is a region of major mineral exploration, also.

Reservoir rocks. Past production has been from freshwater limestones and tuffs of the Eocene Sheep Pass Formation. Other potential reservoirs are the Permian Meade Park Shale Member of the Phosphoria Formation, the Mississippian Deseret Limestone and Chainman Shale and the Devonian Pilot Shale. Other Mesozoic and Paleozoic sandstones and carbonate rocks may be potential reservoirs.

Traps. Stratigraphic traps, including sandstone lenses and changes in carbonate facies, are probable traps in this area. Folds and faults are very likely traps. Combinations may be most important.

Source rocks. Potential source rocks include the Tertiary Elko Formation and Sheep Pass Formation; the Upper Cretaceous Newark Canyon Formation; the Permian Meade Park Shale Member of the Phosphoria Formation; the Mississippian Deseret Limestone; and Chainman Shale; the Devonian Pilot Shale and Woodruff Formation; and the Ordovician Vinini Formation. Source rocks are moderately mature to severely altered in the province. Other shales and carbonate rocks may be potential source rocks in the area.

P-630, SOUTHEASTERN CALIFORNIA BASINS

This province includes the Mojave Desert, Salton Trough and Peninsular Ranges. Little is known about this nonproductive province. Marine Tertiary rocks are potential targets near San Diego adjacent to the San Andres fault and along the Colorado River. The region has limited hydrocarbon potential.

P-640, SACRAMENTO BASIN

The Sacramento basin is the northern portion of California's Great Valley. It is bounded on the east by the Sierra Nevada Mountains, on the northeast by the Cascade Mountains, on the north by the Klamath Mountains and on the west by the Coastal Ranges. It is separated from the San Joaquin basin by the Stockton arch. The Sacramento basin is about 200 miles long and 70 miles wide. It is a structural and stratigraphic basin. Over 30,000 feet of sediments were deposited in the deepest portion of the basin. These rocks are Upper Cretaceous and younger in age. Much of the basin is veneered with Holocene and Pleistocene alluvial deposits. This is an important natural gas province; most of it is non-associated gas.

Reservoir rocks. The producing horizons in this province are Upper Cretaceous to Eocene in age. All are sandstones. They include the Eocene Domenigine Sandstone and Capay Formation; the Paleocene Meganos and Martinez Formations and the Upper Cretaceous Starkey, Winters, Kione and Forbes Formations.

Traps. In this province, most gas accumulations are found in structural/stratigraphic trap combinations. Anticlines and faulted anticlines are very important. Most sandstones are either lenticular in nature or are submarine canyon deposits. Truncations and onlapping occur.

Source rocks. Numerous organic-rich shales were deposited with and between the sandstone units. Potential source rocks include the Starkey, Winters, Kione and Forbes Formations. Many Paleocene and Eocene shales may also be source rocks.

P-650, SAN JOAQUIN BASIN

The San Joaquin basin occupies the southern portion of California's Great Valley. It is an asymmetrical basin with its axis in the western part of the valley. The San Joaquin basin is approximately 250 miles long and 50 to 60 miles wide. It is bounded on the east by the Sierra Nevada Mountains, on the south by the Tehachapi Mountains, on the west by the Coast Ranges and on the north by the Stockton arch. It is a structural and stratigraphic basin. More than 31,000 feet of Cretaceous and younger sediments were deposited in this basin. Most of this is marine shales and sandstones, though continental deposits occur in younger intervals. The eastern portion of the basin is gently folded and faulted. The western portion is highly folded and thrust faulted. Sediments were deposited from both eastern and western sources. This results in different stratigraphy for the eastern and western portions of the province.

The San Joaquin basin is an important hydrocarbon province. The southern part of the basin mainly produces oil and associated/dissolved gas. Nearly all of this production is from Miocene and younger rocks. The northern part of the basin is an area of mostly non-associated natural gas production.

Reservoir rocks. Nearly all reservoir rocks in the basin are sandstones. These range in age from Upper Cretaceous to Pleistocene. Included is the Upper Cretaceous to Tertiary Moreno Formation and numerous Tertiary and Pleistocene units. Some production is from Miocene fractured shales and from fractured basement schists.

Traps. All producing fields in the basin involve more than one trapping style. Anticlines and faulted anticlines are common and may be combined with one or more stratigraphic mechanisms. Common stratigraphic traps include sandstone pinchouts, truncations and diagenetically altered permeability.

Source rocks. Most of the shales in the basin are sapropelic. All are mature and are probable source rocks.

Trends. Producing trends in the province are the Bakersfield arch, West Side, East Side, Central Valley, South End Overthrust area, Paloma Deep production and the Northern Gas Province.

P-600, OREGON–WASHINGTON COASTAL BASINS, OKANOGAN PROVINCE

Selected Major Natural Gas Fields--Cumulative Production and Proved Reserves

Following is the estimate of cumulative production and remaining proved reserves for the only natural gas field in the Oregon-Washington Coastal Basins, Okanogan province. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves and industry sources.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Mist	18,909	16,614

P-640, SACRAMENTO BASIN

Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major natural gas fields in the Sacramento basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Rio Vista (incl. Isleton)	3,221,581	178,419
Union Island	146,021	153,979
Oakley, South	51,621	103,379
Grimes	426,048	95,952
Lindsey Slough	196,793	93,207
Lathrop	322,127	30,873
Malton-Black Butte	87,080	27,920
Todhunter's Lake	82,119	27,881
Sutter Buttes	167,166	27,834
Maine Prairie	141,506	23,494
Denverton Creek	7,232	22,768
Tisdale	27,606	22,394
Conway Ranch	27,515	17,485
Bunker	75,927	17,373
Willows-Beehive Bend	333,008	16,992
Ryer Island	119,427	15,573
Sutter City	89,894	15,106

P-640, SACRAMENTO BASIN
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Pliocene	Tehama Formation	sandstone, shale
Miocene-Pliocene	Sycamore Formation	sandstone, shale, volcanics
Miocene	San Pablo Group	sandstone, shale
	Monterey Group	shale, sandstone
	Claremont Shale	shale
	Sobrante Sandstone	sandstone
Oligocene	Kirker Formation	volcanics, shale, sandstone
Eocene	Markley Formation	sandstone, shale
	Nortonville Shale	shale, sandstone
	Domengine Formation	sandstone, shale
	Capay Formation	shale, sandstone
Paleocene	Martinez Formation	sandstone, shale
Mesozoic		
Cretaceous		
Late	Deer Valley Formation	sandstone, shale
	Starkey Sandstone	sandstone
	Sawtooth Shale	shale, sandstone
	Winters Sandstone	sandstone
	Lathrop Sandstone	sandstone
	Sacramento Shale	shale
	Kione Sandstone–Forbes Shale	sandstone, shale
	Guinda Sandstone	sandstone
	Funks Shale	shale
	Sites Sandstone	sandstone
	Yolo Shale	shale
	Venado Sandstone	sandstone
Early	Budden Canyon Fm.	sandstone, shale
L. Jurassic-E. Cret.	Stony Creek Formation	shale
Jurassic (?)	Franciscan Series	sedimentary and metamorphic rocks

P-650, SAN JOAQUIN BASIN
Generalized Stratigraphic Section

AGE	FORMATION AND LITHOLOGY		
	North	West	East
Cenozoic			
Pleistocene	Tulare Fm.–ss, sh	Tulare Fm.–ss, sh	
Pliocene	San Joaquin Fm.–ss, sh	San Joaquin Fm.–ss, sh	Kern River Fm.–ss, sh
Miocene-Pliocene	Etchegoin Fm.–ss	Etchegoin Fm.–ss	Chanac Fm.–ss, sh
	Reef Ridge Sh.–sh	Reef Ridge Sh.–sh	
Miocene	McLure Sh.–sh, ss	Monterey Fm.–sh, ss	Santa Margarita Ss.–ss
			Fruitvale Sh.–sh
	Temblor Fm.–ss, sh		Temblor Fm.–sh, ss, silt
		Temblor Fm.–ss, sh	Olcese Ss.–ss
			Freeman Jewett Slts.–sh,silt,ss
	Burbank Sand–ss		Vedder Sand–ss
Oligocene	Wherley Sh.–sh		
	Vaqueros Ss.–ss		Walker Fm.–ss,sh
	Tumey Fm.–sh	Tumey Fm.–sh	
	Kreyenhagen Sh.–sh	Kreyenhagen Sh.–sh	
	Adams Ss.–ss	Lodo Fm.–ss, sh	
	Arroyo Hondo Fm.–sh		
Paleocene	"Martinez" Fm.–ss		
Late Cretaceous- Paleocene	Moreno Fm.–ss, sh		
Mesozoic			
Late Cretaceous- Early Cretaceous	Panoche Gp.–ss, sh		
Early Cretaceous	Fresno Springs Canyon Sh.–sh		
	Gravelley Flat Fm.–ss, sh		
	Wisenor Fm.–ss, sh		
Late Jurassic (?)	Franciscan rocks–ss, sh, chert, ls, schist		

P-660, CALIFORNIA COASTAL BASINS

This province is made up of the Coast Ranges, Transverse Ranges and six small basins. Large quantities of oil, associated/dissolved and non-associated gas are produced in this province. Most production occurs in the southern basins.

The Los Angeles basin is a triangular region about 70 miles long and 40 miles wide and extends offshore. It covers approximately 1,450 square miles. It is bounded on the north by the San Gabriel Mountains, on the southeast by the Santa Ana Mountains and on the south by other parts of the Peninsular Ranges. More than 31,000 feet of Miocene and younger sediments fill the deeper parts of the basin. Most of the basin is covered by Pleistocene alluvial deposits. Basin deformation began in the Miocene and culminated in the mid-Pleistocene. Major faults and folds trend northwesterly across the basin.

The Ventura basin is a long eastward-trending re-entrant. It is bounded by two of the Transverse Ranges. Most of this basin is offshore. Compressional forces have formed east-trending anticlines and thrust faults in the basin. As much as 55,000 feet of sediments were depostied within the onshore portion of this basin.

The Santa Maria basin is a wedge-shaped re-entrant in the Coast Ranges. Sedimentary rocks are confined to 30 miles onshore but extend offshore. East-trending elongate folds cross the region.

The Santa Cruz basin is a wedge-shaped coastal basin. It covers approximately 260 square miles. It is bounded on the north and east by the San Andreas fault and Franciscan basement rock outcrops and on the south by Monterey Bay.

The Salinas-Cuyama basin is an elongate, northwest-trending onshore basin. It is about 160 miles long and 28 miles wide and covers 3,100 square miles. It is bounded on the southwest by the Naciemento fault zone and on the northeast by the San Andreas fault zone. It contains more than 15,000 feet of Tertiary sedimentary rocks.

The Humboldt or Eel River basin is in northwestern California. It is triangular in shape and covers 575 square miles. It is bounded on the northeast and south by up-thrown basement rocks. It contains more than 12,000 feet of Miocene and younger rocks. Basin deformation occurred during the Pleistocene.

Reservoir rocks. The reservoir rocks in the Los Angeles basin are the Pliocene Pico and Repetto Formations; the Miocene Puente and Topango Formations and the fractured Jurassic Catalina Schist. Of these, the Repetto Formation is the most prolific. Reservoir rocks in the Ventura basin are the Pliocene Pico and Repetto Formations; the Miocene Rincon Claystone and Vaqueros Formation; the Eocene-Oligocene Sespe Formation and the Eocene Coldwater Sandstone. Of these, the Pliocene and Miocene are the most prolific. In the Santa Maria basin, the reservoir rocks are the Pliocene Foxen and Sisquoc Formations; the Miocene Monterey Formation; the Oligocene-Miocene Point Sal and Lopse Formations and the Jurassic Knoxville Formation. Much of the production in this basin is from fractured reservoirs in cherts, shales and tight sandstones. In the Salinas-Cuyama basin, the main reservoirs are the Miocene Dibble Sandstone and the Miocene Lombardi Sandstone. In the Santa Cruz basin, production is from Eocene sandstones. Probable reservoirs in the Humboldt basin are the Pliocene Scotia Bluff Sandstone, Rio Dell Formation and Eel River Formation and the Miocene Pullen Formation.

Traps. The major trapping mechanisms in the Los Angeles basin and Humboldt basin are anticlines, faults and faulted anticlines. These are important trap formers in the other basins as well. Other trapping mechanisms include sandstone lenses, truncations and porosity variations in the Santa Maria basin. Sandstone pinchouts occur in all basins. Onlapping sandstones form traps in the Salinas-Cuyama basin. Fracture porosity is important in the Los Angeles, Santa Maria and Ventura basins.

Source rocks. The Miocene Monterey is a likely source rock in the Ventura, Santa Maria and Salinas-Cuyama basins. The Miocene Rincon Claystone is a probable source rock in the Ventura basin. In the Los Angeles basin, the source rocks are the Pliocene Repetto Formation and the Miocene Puenta and Modelo Formations. In the Humboldt basin, the probable source rocks are the Pliocene Rio Dell and Eel River Formations and the Miocene Pullen Formation.

P-660, CALIFORNIA COASTAL BASINS
Generalized Stratigraphic Section

AGE	FORMATION AND LITHOLOGY		
	Los Angeles basin	Ventura basin	Santa Maria basin
Cenozoic			
Pleistocene	San Pedro Fm.-- La Habra Fm.-ss, sh	San Pedro Fm.-- Saugus Fm.-ss, cong Santa Barbara Fm.-sh	Orcutt Fm.-ss Paso Robles Fm.-- Santa Barbara Fm.-sh, ss
Plio-Pleist.	Fernando Fm.-- San Diego Fm.-ss, sh		
Pliocene	Repetto Fm.-ss, sh	Pico Fm.-- Sunshine Ranch Fm.-ss, sh	Careaga Ss.--Morales-- Foxen Muds.-sh, ss
Mio-Pliocene	Capistrano Fm.-- Olay Fm.-ss, sh	Ridge Basin Gp.-- Towsley Fm.-ss, sh, cong	Sisquoc Fm.-silt, ss
Miocene	Puente Fm.-- Monterey Fm.-sh, ss "Santa Margarita"-ss San Onofre Breccia Topanga Fm.-ss	Monterey--Castaic-- Mint Canyon-- Modelo Fm.-ss,sh Topanga Fm.--ss, cong, vol Tick Canyon Fm.-cong	Santa Margarita Fm.-- Monterey Fm.-- Point Sal Fm.-sh, ss Lopse Fm.-- Rincon Sh.-sh
Olig.-Miocene	Vaqueros Fm.-ss	Vaqueros Fm.-- Vasquez Fm.-sh, ss	Vaqueros Fm.-ss, sh
Oligocene			Simmler--Alegria-- Sespe Fm.-ss, cong, sh
Olig.-Eocene	Sespe Fm.-ss, cong	Sespe Fm.-ss, cong	
Eocene	Santiago Fm.-- Poway Gp.-- La Jolla Gp.-ss, sh, cong Matilija Fm.-ss	Coldwater Ss.--ss Cozy Dell Sh.-- Llajas Fm.-sh Matilija Fm.-ss Santa Susana Fm.-sh	Sacate Fm.--ss, sh Cozy Dell Sh.-sh
Paleo.-Eocene			Pattiway Fm.-- Anita Fm.-ss, sh
Paleocene	Silverado Fm.-ss, sh	"Martinez" Fm.-- Coal Canyon Fm.-ss,cong	
Mesozoic			
Cretaceous			
Late	Rosario Gp.--Williams-- Ladd--Lusardi Fm.-ss, cong, sh Trabuco Fm.-cong	Chatsworth Fm.-- Tuna Canyon Fm.-ss, sh	Jalama Fm.-sh, ss
Early	missing	missing	Espada Fm.-ss, sh
Jurassic			Knoxville Fm. and Franciscan rocks

P-960 AND P-961, PACIFIC OFFSHORE, SHELF AND SLOPE

Many of the coastal deposits extend offshore. These deposits are especially important in the southern California regions. The Los Angeles, Ventura and Santa Maria basins all extend offshore. As much as 58,000 feet of sediments lie in the offshore Ventura basin. Present production is confined to these offshore extensions. This region has good potential. Offshore Oregon and Washington has some potential. The shelf is 30 to 40 miles wide here. There is presently no production in offshore Washington or Oregon. Offshore southern California is composed of numerous horsts and grabens.

Reservoir rocks. Reservoir rocks in the California Offshore area include both sandstones and fractured shales. These range in age from Eocene to Pliocene. Included are the Eocene Sacate and Cozy Dell, the Oligocene Sespe, Alegria and Gaviota, the Miocene Vaqueros, Rincon, Monterey fractured shales and Puente and the Pliocene Repetto and Pico.

Traps. All producing fields involve faulted anticlines. Stratigraphic mechanisms such as truncations, sandstone pinchouts and diagenetically altered permeability also affect production.

Source rocks. Pliocene shales, the Miocene Monterey Formation and the Miocene Rincon Claystone are probable sources of most of the hydrocarbons.

P-650, SAN JOAQUIN BASIN
Selected Major Natural Gas Fields–Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for selected major natural gas fields in the San Joaquin basin. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Elk Hills	472,790	1,389,823
Gill Ranch	63,108	2,692
Trico	200,346	654

P-960 and P-961, PACIFIC OFFSHORE, SHELF AND SLOPE
Selected Major Natural Gas Fields--Cumulative Production and Proved Reserves

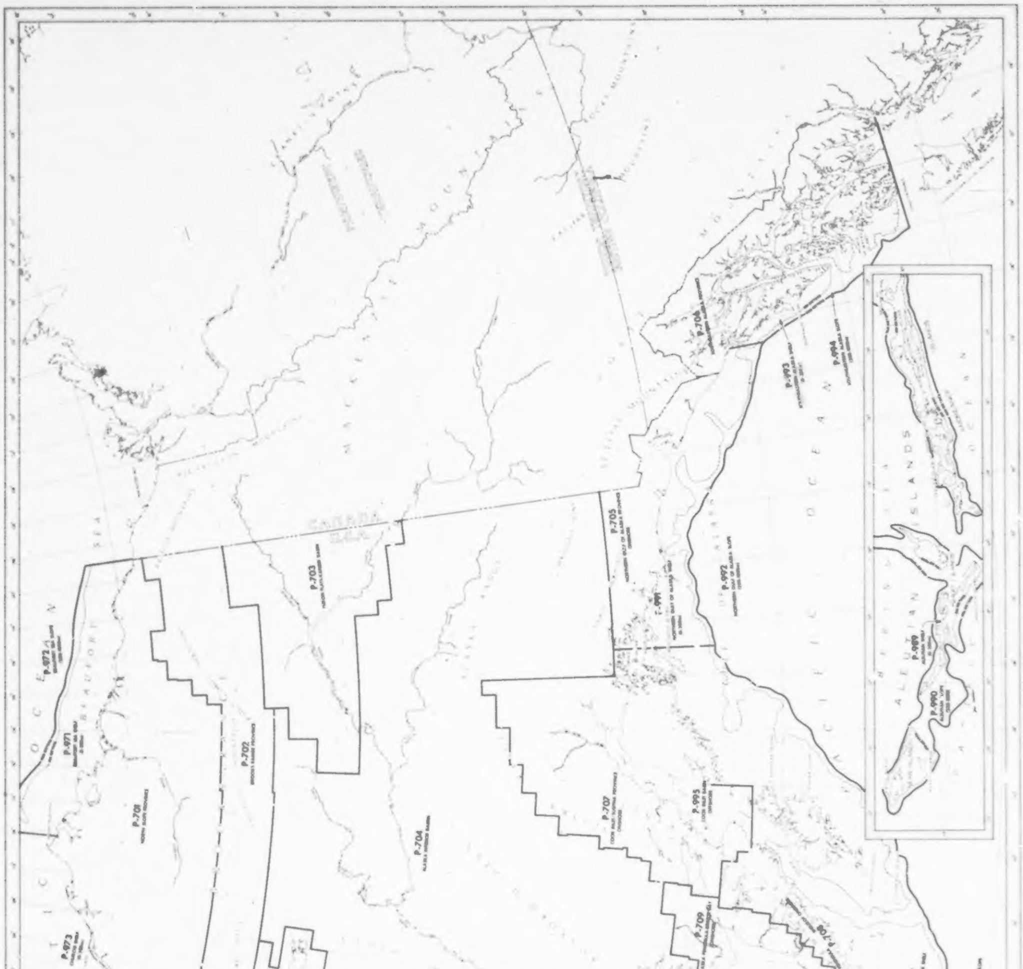
Following are estimates of cumulative production and remaining proved reserves for selected major natural gas fields in the Pacific Offshore region. They represent only a sampling of the fields within the province for which data are available. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Pitas Point	16,111	233,889
Molino	236,792	33,208

Table 16. Estimated resources of natural gas for provinces of the Pacific Area, December 1984 (billion cubic feet).

PROVINCE	ONSHORE	OFFSHORE		PROBABLE			POSSIBLE			SPEC.	
	depth	water depth	Max.	M. likely	Min.	Max.	M. likely	Min.	Max.	M. likely	Min.
P-600, Oregon-Washington	0-15,000'		20	15	10	2,000	1,000	300	5,000	1,700	*
coastal basins, Okanogan	15-30,000'								2,000	*	*
P-610, Eastern Columbia	0-15,000'								3,000	1,000	*
Basin	15-30,000'								2,000	*	*
P-620, Great Basin-	0-15,000'								2,000	700	*
Southern Oregon	15-30,000'								1,000	*	*
P-630, Southeastern	0-15,000'								1,000	500	*
California basins	15-30,000'								*	*	*
P-640, Sacramento	0-15,000'		1,200	700	300	3,500	1,700	800	5,000	1,500	*
basin	15-30,000'								*	*	*
P-650, San Joaquin	0-15,000'		500	250	150	1,000	750	500	500	*	*
basin	15-30,000'					1,000	550	*	1,500	500	*
P-660, California	0-15,000'		800	500	250	3,500	2,100	900	1,300	600	200
coastal basins	15-30,000'		300	200	200	1,200	600	400	600	400	100
P-960, Pacific shelf		0-200 m	110	74	50	7,575	4,735	2,840	7,745	3,661	880
P-961, Pacific slope		200-1,000 m	275	182	120	6,685	4,178	2,505	9,665	5,167	2,035
TOTAL, onshore	0-15,000'			1,465			5,550			6,000	
TOTAL, onshore	15-30,000'			200			1,150			900	
TOTAL, onshore, all depths				1,665			6,700			6,900	
TOTAL, offshore		0-200 m		74			4,735			3,661	
TOTAL, offshore		200-1,000 m		182			4,178			5,167	
TOTAL, offshore, all depths				256			8,913			8,828	
GRAND TOTAL FOR AREA				1,921			15,613			15,728	

*Negligible quantity of natural gas estimated


ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
BERING SEA
PACIFIC OCEAN
ALEUTIAN ISLANDS
BRISTOL BAY
SEWARD PENINSULA
MACKENZIE MOUNTAINS
CANADA
U.S.A.
P-972
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ALASKA AREA

With a total area of approximately 1.15 million square miles (about half of which is on land, the other half is between the shoreline and the -1,000-meter isobath), Alaska is a vast frontier. Oil production has been established on the North Slope and in the Cook Inlet area to the south (WSW of Anchorage). Natural gas production is currently restricted to the Cook Inlet area because of the lack of pipeline systems to bring North Slope gas to market.

Tectonically and stratigraphically, Alaska includes parts of the Rocky Mountain and Western North American Borderland settings. Producing, and prospectively productive, intervals are of Paleozoic age or younger. Geologic structures include both folds and faults. Reservoir lithologies range from sandstones to carbonate rocks.

The main emphasis of exploratory efforts is currently focused on the North Slope- Beaufort Sea and Bering Sea areas. Despite the drilling of the most costly dry wildcat well ever drilled, the Beaufort Sea is considered to have tremendous potential. Leasing activity in 1983 was dominated by OCS sales in the Norton and St. George basins of the Bering Sea. The Arctic National Wildlife Refuge remains among the most promising untested onshore acreage in the United States.

The Cook Inlet basin has been without major oil and/or gas discoveries for several years. Disappointing results have also been reported from the Yakutat offshore area of the Gulf of Alaska.

P-701, ALASKA NORTH SLOPE

The Alaska North Slope geologic province includes a total of 54,610 square miles and extends from the Beaufort Sea in the north to the Brooks Range in the south. The majority of Alaska's oil production currently comes from this area and is concentrated along the Barrow arch trend. The province also contains large reserves of natural gas, but there is no current production because of the lack of pipeline facilities to transport the gas.

Reservoir rocks. Deposition along the Barrow arch took place in a linear, downfaulted basin located along a stable, passive cratonic margin. Potential reservoir rocks consist largely of Mississippian to Tertiary clastic rocks deposited in this basin. Current production comes from the Ellesmerian sequence of rocks, ranging in age from Mississippian to earliest Cretaceous, and from the Brookian sequence, ranging in age from Early Cretaceous to Tertiary. Principal sandstone reservoirs include the Permo-Triassic Sadlerochit Group (oil and gas), Triassic Sag River Formation (oil and gas), Early Cretaceous Kuparuk River Formation (oil and gas), sandstones of the Early Cretaceous Nanushuk Group (oil and gas), sandstones of the Late Cretaceous Colville Group (oil), Late Cretaceous West Sak sands (oil), and Tertiary Sagavanirktok Formation (gas). Carbonate reservoirs include the Mississippian-Pennsylvanian Lisburne Group (oil) and the Triassic Shublik Formation (oil and gas).

Traps. Accumulations in the Ellesmerian sequence are trapped by combinations of folding, faulting, and truncation by a major unconformity at the base of the Brookian sequence (Lower Cretaceous unconformity). Seals are generally provided by overlying shales or other less permeable rocks. Brookian sequence hydrocarbon accumulations appear to be due primarily to stratigraphic changes. Permafrost is believed to be a trapping mechanism for gas accumulations in the younger Brookian sequence.

Potential source rocks. Shales contained in Mississippian, Permian, Jurassic, Cretaceous and Tertiary sequences are the most likely source rocks for the hydrocarbon accumulations.

Future exploration. Based on the successful exploration efforts to date, the main exploratory interest in Alaska remains in the North Slope province and the adjacent Beaufort Sea province. Seven out of the 12 exploratory wells drilled in 1983 in Alaska were situated in this area.

ALASKA
Cumulative Production and Remaining Proved Reserves

Following are estimates of cumulative production and remaining proved reserves for Alaska. Data are for the entire state and include all fields. Data have been obtained from the American Gas Association Committee on Natural Gas Reserves.

Field	Cumulative Production (12/31/84) (million cubic feet)	Remaining Proved Reserves (12/31/84) (million cubic feet)
Alaska	3,182,882	31,144,858

P-701, ALASKA NORTH SLOPE
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Quaternary	Gubik Formation	gravels, sands, silts, clays
Tertiary	Brookian sequence	
	Sagavanirktok Formation	gravels, sands, silts, clays
Mesozoic		
Late Cretaceous	Colville Group	
	Prince Crk. Fm.	shale, sandstone
	West Sak sands	sandstones
	Seabee Fm.	shale
Early Cretaceous	Nanushuk Group/unnamed shale	sandstone, conglomerate,shale
	Okpikruak Fm.	conglomerate, shale
	Ellesmerian sequence	
	Kuparuk R. Fm.	sandstone
Jurassic	Kingak Shale	shale
Triassic	Karen Crk. Ss./Sag River Fm.	sandstone, conglomerate
	Shublik Formation	carbonate
	Sadierochit Group (Ivishak Ss.)	sandstone, conglomerate, shale
Paleozoic		
Permian		
Pennsylvanian	Lisburne Group	carbonates
Mississippian	Endicott Group (Kekiktuk Formation)	sandstone, conglomerate
Pre-Mississippian		basement complex

P-702, ALASKA SOUTHERN FOOTHILLS AND BROOKS RANGE

This province encompasses the Brooks Range from the foothills in the north to the Koyukuk, Yukon Flats and Kandik basins which form the southern border. The area of the entire province totals 65,373 square miles. Tectonically the province has been classified as a deformed cratonic margin which has been associated with strong folding and overthrusting.

No oil or gas fields or producing trends have been established in this province to date. However, the occurrence of bitumen, solid hydrocarbons and oil shale (Tasmanite) of Early Cretaceous age have been reported.

Reservoir rocks. Potential reservoir rocks range from Devonian reef carbonates of the Hunt Fork-Beaucoup Formation to the Cretaceous Torok Shale. Other potential reservoir rocks are included in the Endicott Group (Devonian-Mississippian), the Skajit Formation (Devonian-Silurian), Lisburne Group (Mississippian-Pennsylvanian), Shublik Formation (Triassic), and Fortress Mountain Formation (Early Cretaceous).

Traps. Prospective traps are considered to be related to thrust faults and faulted anticlines.

Potential source rocks. Shales and carbonate rocks, ranging in age from Devonian to Cretaceous are considered to be potential sources of hydrocarbons. These formations include Kayak Shale (Mississippian), "Kavik" Formation (Mississippian), Kingak Shale (Jurassic), and "pebble shale" (Early Cretaceous).

P-703, YUKON FLATS BASIN AND KANDIK BASIN

This province includes a surface area of over 30,000 square miles and is divided into the Kandik basin and the Yukon Flats basin. Both basins are considered intermontane with sedimentary section possibly exceeding 20,000 feet. The one exploratory well in the Kandik basin encountered tectonically repeated overly mature Mesozoic rocks. The two exploratory wells in the Yukon Flats basin were drilled in the extreme northeast margin and encountered thermally mature Paleozoic rocks at total depth. Although only three wells have been drilled in this province, the prospect for gas production appears small.

P-704, ALASKA INTERIOR BASINS

This province stretches over nearly 260,000 square miles from the southern foothills of the Brooks Range in the north to the Alaska Range and the Chugach Mountains in the south. It is bordered on the west by the Bering Sea and on the east by the Canadian border. Several sedimentary basins are included in the province: Bethel basin, Inoko basin, Lower Tanana basin, Holitna basin, Yukon delta (onshore portion of Norton basin), Minchumina basin, Middle Tanana basin and Copper River basin. No production of oil or gas has been established in this province. However, the Bethel basin, Copper River basin, Minchumina basin, and Holitna basin are thought to have some potential for future natural gas production.

The southeastern basins generally contain Tertiary rocks overlying Precambrian basement. Generally, the shallow intermontane Minchumina and Middle Tanana basins contain non-marine molasse sediments which are thermally immature. Apart from coaly and carbonaceous material, the organic carbon content is low.

The northwestern portion of the province includes a thin Tertiary section which is probably thermally mature but contains a low organic carbon content. The Cretaceous section is thermally overmature. No shows have been reported in wells drilled to date.

The Copper River basin is a topographic basin floored with unconsolidated deposits of Quaternary age. In at least two localities in the south-central part of the basin, flammable methane gas associated with saline springs seeps through the Quaternary sediments. Mesozoic sediments crop out along the periphery of the basin. Exposures indicate a thick section of both Upper and Lower Cretaceous rocks underlain by a thinner sequence of Jurassic rocks, which in turn are underlain by a series of Upper Triassic sedimentary rocks. Both the Jurassic and Cretaceous rocks are of marine origin and contain potential source rocks, in the form of organic shales, and potential reservoir sandstones. Triassic carbonates are also considered to be potential reservoirs. Wells drilled to date in the Copper River basin have encountered minor gas shows.

P-705, NORTHERN GULF OF ALASKA (ONSHORE)

This province encompasses approximately 15,000 square miles. It is bordered on the north by the Chugach Mountains, on the south by the Gulf of Alaska and on the east by the Canadian border. The major tectonic elements include the Yakataga and Yakatat basins. Nearly all rocks are of Tertiary age and consist almost entirely of detrital units. Prospective reservoir rocks range in age from Eocene to Miocene.

Oil production has occurred in the Katalla trend, on the shore of the Gulf of Alaska east of Cordova, which is the only established production in southern Alaska outside of the Cook Inlet area. Oil and gas seeps were discovered in the Katalla area about 1896 and the first successful well was drilled in 1902. A small refinery was built in 1911, but it burned down in 1933 and there has been no production at Katalla since then. About 36 wells were drilled, all comparatively shallow, from 550 to 750 feet in depth. Total oil produced from the field was about 154,000 barrels. Later onshore exploratory wells in the province have encountered minor oil and gas shows.

P-706, SOUTHEASTERN ALASKA

This province is bordered on the north, south and east by the Canadian border and by the Pacific Ocean on the west. It covers a total area of about 31,000 square miles. No oil or gas production has been established in the province to date. Most rocks in the province have undergone intense deformation so that it is difficult to assess their petroleum potential, if any. Predominantly they consist of metamorphic and crystalline rocks.

P-707, COOK INLET--SUSITNA PROVINCE (ONSHORE)

This province encompasses a total area of 45,568 square miles. The province is bounded on the north and west by the Alaska Range and by the Chugach and Cook Inlet in the south. The major tectonic elements include the Susitna basin, Matanuska Valley, Cook Inlet basin and Augustine-Sedovia arch. Producing trends established to date are the Sterling/Beluga trend and the Hemlock/Tyonek/West Foreland trend. A few oil and gas seeps, as well as subsurface shows, have been reported. Several gas fields and two oil fields are on production from this province.

Reservoir rocks. All prospective intervals consist of detrital rocks, mainly sandstones, and mainly of Tertiary age.

Traps. Both structural and stratigraphic traps occur at all reservoir levels. All production thus far is from anticlines and faulted anticlines. Caprocks include the Kenai Group siltstone (Oligocene-Pliocene) and the siltstone unit of the West Foreland Formation (Paleocene).

Potential source rocks. The Tertiary Kenai Group shales and claystones are considered to be potential source rocks for gas. The mid-Jurassic Naknek Formation is considered capable of generating both oil and gas.

P-707, COOK INLET–SUSITNA PROVINCE (ONSHORE)
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Tertiary	Kenai Group	
	Sterling Formation	sandstone and siltstone
	Beluga River Formation	congl., sandstone, siltstone, and claystone
	Tyonek Formation	congl., sandstone, siltstone, claystone, coal
	Hemlock Formation	congl., sandstone
	West Foreland Formation	congl.,sandstone and claystone
	Chickaloon Formation	siltstone, sandstone, coal
Mesozoic		non-marine clastic rocks
Cretaceous	Kaguyak Formation	sandstone, shale
	Matanuska Formation	sandstone, shale
	unnamed	sandstone, shale
Jurassic	Naknek Formation	sandstone, shale
	Chinitna Formation	sandstone, shale
	Tuxedni Group	congl., sandstone, shale
	Talkeetna Formation	pyroclastics, volcaniclastics

P-708, ALASKA PENINSULA--SHELIKOF PROVINCE (ONSHORE)

This province encompasses a total area of 12,777 square miles. It is bordered on the north and west by the Aleutian Range and on the southeast by the Shelikof Strait. The major tectonic elements include the Wide Bay and Chignite anticlines, and the Pearl Creek dome. The major stratigraphic units range in age from Triassic to Tertiary. Sandstone and conglomerate units form all reported potential reservoirs. No oil or gas production has been established in the province although several wells reported oil shows.

P-709, ALASKA PENINSULA--BRISTOL BAY (ONSHORE)

This province includes 22,187 square miles in southwestern Alaska. No production has been established, but potential for oil and both associated/dissolved and non-associated gas is envisaged. The region is bordered by the Aleutian Range in the south and southeast and by Bristol Bay in the southwest. Sedimentary rocks range in age from Jurassic to Pliocene and potential source and reservoir rocks exist throughout the section. Sandstones are the dominant lithology. A variety of structural and stratigraphic traps may exist. Wells drilled in the province have encountered minor oil and gas shows.

P-710, ALEUTIAN ISLANDS

This province includes the land area of the Aleutian Islands. It is located to the southwest of the Alaska Peninsula and encompasses a large number of mainly volcanic islands. The volcanic nature of the islands suggests negligible potential for natural gas.

P-971 AND P-972, BEAUFORT SEA SHELF AND SLOPE

These provinces cover a total area of approximately 40,000 square miles. To date, oil and gas production has not been established, but estimates of potential for the shelf area are optimistic. No estimate has been made for potential which might exist below the continental slope at water depths from 200 to 1,000 meters because this area lies below the polar ice pack.

Reservoir rocks. Potential reservoir rocks are similar to the section in the adjacent onshore areas of the North Slope. The stratigraphic section contains rocks which range in age from Mississippian to Tertiary and are dominantly clastic rocks with the exception of Mississippian carbonates. Most of the prospective reservoir rocks occur in the Permo-Triassic section, but there are also some prospects in the Tertiary section to the east.

Traps. Stratigraphic traps are believed to be abundant. They include pinchouts (in Tertiary and Cretaceous units), truncations (Jurassic and Triassic rocks), and onlap in the Mississippian sequence. Structural traps are also postulated related to both folding and faulting.

Potential source rocks. Potential source rocks for both oil and gas exist in the Mississippian to Early Cretaceous sequence and in Late Cretaceous-Tertiary rocks. The rocks range from thermally immature to very mature.

Future exploration. Most of the exploration plays to date consist of extensions of onshore trends. The difficulties of interpretation are exemplified by recent dry holes. The enormous potential of the adjacent onshore area and the likelihood of extensions of similar conditions into the offshore area are stimulants to continued exploration in spite of high costs and difficult conditions.

P-973, CHUKCHI SHELF

This province covers an area of approximately 61,000 square miles. No oil or gas production has been established to date. Potential reservoir rocks range in age from Mississippian to Tertiary. The rocks are predominantly clastic, although prospective reservoirs in Mississippian-age rocks are limestones and dolomites. Both stratigraphic and structural traps are anticipated. There has been no exploratory drilling to date in this province.

P-974, NORTON BASIN

This province covers an area of over 43,000 square miles. No oil or gas production has been established to date. Prospective reservoir rocks range in age from Cretaceous to Tertiary and consist mainly of sandstones. Stratigraphic and structural traps are anticipated and have been noted in Tertiary rocks. Gas seeps, rich in carbon dioxide, have been reported from the area.

P-975, HOPE BASIN

This province is dominantly an offshore area, including mainly Kotzebue Sound and parts of the Bering Strait, but it also extends onshore to include a small area of the Seward Peninsula. Sedimentary rocks in the area range in age from Cretaceous to Tertiary. No natural gas or oil production has been established in the province.

The onshore portion is considered to have low potential for natural gas production. It contains a thin section of thermally immature, non-marine Tertiary sandstones, conglomerates and shales. The offshore portion has a thicker sedimentary section and is considered to have some potential from rocks of Cretaceous and Tertiary age. Both structural and stratigraphic traps may exist. Potential source rocks are primarily of Tertiary age.

P-979, ST. MATTHEW BASIN--BETHEL BASIN SHELF

This province includes an area of more than 91,000 square miles. No oil or natural gas production has been established, and the province is not considered to have potential for future natural gas production primarily due to a thin section of thermally immature rocks.

P-980, SOUTHWEST BERING SEA SLOPE

Water depths in this province are all greater than 1,000 meters. No estimate of natural gas potential has been made at this time.

P-981 AND P-982, NAVARIN BASIN, SHELF AND SLOPE

These provinces include an area of approximately 49,000 square miles covered by water depths of less than 1,000 meters. Sedimentary rocks range in age from Jurassic to Tertiary, and detrital units predominate. No production of natural gas or oil has been established in these provinces to date. Potential reservoir rocks are of Jurassic, Cretaceous and Tertiary age. Both stratigraphic and structural traps are believed to occur. Pinchouts generally occur in Tertiary strata, whereas truncations and onlap are associated with Mesozoic rocks. Anticlines and faulted anticlines are common in Mesozoic as well as Tertiary units. Growth faults and draping also occur in the Tertiary section. Potential source rocks probably exist in the Jurassic, Cretaceous and early Tertiary sections.

P-983 AND P-984, ST. GEORGE BASIN, SHELF AND SLOPE

These provinces encompass an area of approximately 96,000 square miles. No oil or gas production has been established to date. Sedimentary rocks in the provinces are predominantly detrital and range in age from Jurassic to Tertiary. Potential reservoir rocks in the shelf province consist of sandstones of Jurassic, Cretaceous and Tertiary age. In the slope province potential reservoirs for oil and gas are Paleogene turbidites.

P-985, BRISTOL BAY BASIN SHELF

Approximately 55,000 square miles are included in this province which is all covered by water depths of less than 200 meters. Sedimentary rocks are generally detrital and range in age from Jurassic to Tertiary. No natural gas or oil production has been established to date. Potential reservoir rocks are sandstones of Jurassic, Cretaceous and Tertiary age. Both stratigraphic and structural traps occur. Truncations are most common in Mesozoic strata, whereas onlap and pinchouts appear to be restricted to Tertiary units. Faulted anticlines and faults are common at all stratigraphic levels. Potential source rocks are mostly of Cretaceous and early Tertiary age, although Jurassic units may also be a possible source.

P-987 AND P-988, SHUMAGIN-KODIAK SHELF AND SLOPE

This area lies offshore from southern and southwestern Alaska and encompasses an area of over 80,000 square miles. Sedimentary rocks are Cretaceous and younger, but Tertiary detrital units predominate. No natural gas or oil production has been established in the province. Potential for natural gas production is believed to occur in rocks of Tertiary age, generally sandstones, in the Shelf area. Traps may be either structural or stratigraphic. Most potential source rocks are in the Tertiary section.

P-989 AND P-990, ALEUTIAN SHELF AND SLOPE

The Aleutian Shelf and Slope cover an area of almost 85,000 square miles. Most of the rocks are related to the volcanic activity of the Aleutian Islands and to tectonic activity which formed the Aleutian Trench and the Islands. Most of the sedimentary rocks are of younger Tertiary age. No production of natural gas or oil has been established in the province and the potential for future natural gas production is very low.

P-991, P-992, P-993 AND P-994, NORTHERN GULF OF ALASKA AND SOUTH-EASTERN ALASKA SHELF AND SLOPE

These provinces have a combined area of approximately 56,000 square miles. Sedimentary rocks are predominantly of Tertiary age and are generally detrital. No production of natural gas or oil has been established. Potential reservoir rocks include Tertiary formations. Both structural and stratigraphic traps occur and include truncations and onlap as well as anticlines and faulted anticlines. Potential source rocks may occur within the early Tertiary section.

P-995, COOK INLET BASIN-OFFSHORE

This province is the offshore portion of the Cook Inlet basin; the onshore portion is included in province P-707. It covers slightly more than 7,400 square miles. Sedimentary rocks in the province are predominantly detrital and range in age from Jurassic to Tertiary. This, and the adjoining onshore province, is the only area of current natural gas and oil production in Alaska outside of the North Slope. Two trends of natural gas production and two trends of oil production have been established.

Reservoir rocks. Sandstones and conglomerates of Tertiary age are the primary gas and oil reservoirs. The Tertiary Beluga and Sterling Sandstones are productive of gas only.

Traps. Sandstone pinchouts and antinclinal trapping are both common in the Tertiary section. Truncation by unconformities and faulted anticlines are common trapping mechanisms in Mesozoic reservoirs.

Potential source rocks. Thermally immature to mature Tertiary rocks are considered to be a fair source for oil. Late Jurassic, thermally moderately mature to very mature, rocks are considered to be good sources for oil and possibly for gas.

P-991, P-992, P-993, and P-994, NORTHERN GULF OF ALASKA AREA, SOUTHEASTERN ALASKA SHELF AND SLOPE
Generalized Stratigraphic Section

AGE	FORMATION	GENERAL LITHOLOGY
Cenozoic		
Tertiary	Tugidak Formation	sandstone, siltstone, mudstone
	Yakataga Formation	mudstone and sandstone
	Sitkinak Formation-Katalla Formation-Poul Creek Formation	mudstone, siltstone, sandstone
	Tokun Formation	siltstone, sandstone, conglomerate
	Sitkalidak Formation-Orca Group-Kulthieth Formation	sandstone and siltstone
	Ghost Rocks Formation	sandstone
Mesozoic	Kodiak Formation-Valdez Group-Yakutat Group	

Table 17. Estimated resources of natural gas for provinces of the Alaska Area, December 1984 (billion cubic feet).

PROVINCE	ONSHORE	OFFSHORE	PROBABLE			POSSIBLE			SPECULATIVE		
	depth	water depth	Max.	M. likely	Min.	Max.	M. likely	Min.	Max.	M. likely	Min.
P-701. North Slope province	0-15,000'		12,000	6,000	2,000	43,000	15,000	4,000	72,000	23,000	6,000
	15-30,000'								NO RELIABLE DATA		
P-702. Brooks Range province	0-15,000'								1,000	*	*
	15-30,000'									NO DATA	
P-703. Yukon Flats-Kandik basins	0-15,000'								500	180	*
	15-30,000'									NO DATA	
P-704. Alaska Interior basins	0-15,000'								2,500	520	*
	15-30,000'									NO DATA	
P-705. Northern Gulf of Alaska, onshore	0-15,000'								3,550	710	120
	15-30,000'								NO RELIABLE DATA		
P-706. Southeastern Alaska	0-15,000'								*	*	*
	15-30,000'								*	*	*
P-707. Cook Inlet/Susitna province, onshore	0-15,000'		1,600	700	400	2,800	1,400	700	4,800	2,400	*
	15-30,000'								*	*	*
P-708. Alaska Peninsula/Shelikof province, onshore	0-15,000'								320	190	*
	15-30,000'								NO RELIABLE DATA		
P-709. Alaska Peninsula/Bristol Bay province, onshore	0-15,000'								1,400	690	380
	15-30,000'								NO RELIABLE DATA		
P-710. Aleutian Islands	0-15,000'								1,000	*	*
	15-30,000'								NO RELIABLE DATA		
P-971. Beaufort shelf		0-200 m	11,000	2,000	1,000	41,000	12,000	3,000	62,500	19,500	3,500
P-972. Beaufort slope		200-1,000m							NOT ESTIMATED		
P-973. Chukchi shelf		0-200 m							62,500	19,500	3,500
P-974. Norton basin		0-200 m							3,200	1,000	*
P-975. Hope basin		0-200 m							2,000	540	*
P-979. St. Matthew shelf		0-200 m							*	*	*
P-980. Southwestern Bering Sea		>1,000 m				NOT ESTIMATED--ALL WATER DEPTHS GREATER THAN 1,000 m					
P-981. Navarin basin shelf		0-200 m							24,000	6,000	*
P-982. Navarin basin slope		200-1,000m							3,000	1,200	*
P-983. St. George shelf		0-200 m							16,700	10,400	5,220
P-984. St. George slope		200-1,000m							2,500	1,000	600
P-985. Bristol Bay shelf		0-200 m							5,980	3,740	1,870
P-987. Shumagin shelf		0-200 m							5,200	1,720	220
P-988. Shumagin slope		200-1,000m							NOT ESTIMATED		
P-989. Aleutian shelf		0-200 m							1,000	*	*
P-990. Aleutian slope		200-1,000m							*	*	*
P-991. N. Gulf Alaska shelf		0-200 m							7,160	2,370	300
P-992. N. Gulf Alaska slope		200-1,000m							6,540	2,640	440
P-993. SE Alaska shelf		0-200 m							2,600	860	200
P-994. SE Alaska slope		200-1,000m								NO DATA	
P-995. Cook Inlet, offshore		0-200 m	800	400	200	1,400	700	350	2,400	1,000	*
TOTAL, onshore	0-15,000'			6,700			16,400			27,690	
TOTAL, onshore	15-30,000'			*			*			*	
TOTAL, onshore, all depths				6,700			16,400			27,690	
TOTAL, offshore	0-200 m			2,400			12,700			66,630	
TOTAL, offshore	200-1,000 m			*			*			4,840	
TOTAL, offshore, all depths				2,400			12,700			71,470	
GRAND TOTAL FOR AREA				9,100			29,100			99,160	

*Negligible quantity of natural gas estimated

POLICY GUIDELINES

General Policy Statement

An appraisal of the long-range prospects of the natural gas industry in the United States--an appraisal that is useful for financial, managerial and government purposes--requires, as an essential element, scientific, authoritative, and objective estimation of the potential supply of natural gas which may become available to the nation in addition to currently available proved recoverable reserves of natural gas.

The Potential Gas Committee fulfills this requirement by providing periodic estimates of the potential supply of natural gas which may become available. This Committee, together with its several Area Work Committees, is composed of about one hundred fifty individuals from the production, transmission and distribution segments of the natural gas industry who are knowledgeable with respect to the potential supply of natural gas.

The quantities of natural gas included in this report by the Potential Gas Committee are only those which are considered to be recoverable by technology currently available or feasible in the foreseeable future. There are additional, potentially recoverable, quantities of natural gas contained in such situations as gaseous coal seams, geopressured zones, certain black shales, sandstones with very low permeability and gas hydrates. Some workers have postulated large quantities of recoverable natural gas from each of these nonconventional sources, but there still remains considerable question as to the reasonable order of magnitude and the recoverability of this gas. These nonconventional sources largely have not been considered at this time by the Potential Gas Committee because the Committee feels that the technology of recovery has not yet been adequately demonstrated. As technological developments occur, the Committee will further study the potential from these sources and reconsider its estimates.

The Potential Gas Committee and its Area Work Committees discuss matters and data that are confidential. Fulfillment of the objectives of the Potential Gas Committee cannot be realized without the availability and utilization of information of a highly confidential nature. It is, therefore, the policy of the Potential Gas Committee and its Work Committees that every member, observer and representative will respect such information and that there will be no disclosure of information or estimates, discussions, or other data, except as approved for release by the Potential Gas Committee.

A diagram of the organizational structure for the estimation of the potential supply of natural gas is shown in figure 8. A detailed description of the membership and duties of the several committees and of the Potential Gas Agency is presented in the sections which follow.

Membership of Committees and Policy Guidelines for Committees

The structure of the study of the potential supply of natural gas is divided into three parts consisting of the Gas Supply Committee of the American Gas Association, the Potential Gas Agency and the Potential Gas Committee. The organization is shown graphically in figure 8.

GAS SUPPLY COMMITTEE
American Gas Association

William T. McCormick, Jr., Chairman
Robert B. Kalisch, Staff Executive

Objectives, policy, agency selection, financing, industry liaison.

POTENTIAL GAS AGENCY
Colorado School of Mines
Institute for Energy Resource Studies
Supported by the American Gas Association

Harry C. Kent, Director

Approve criteria and methods, insure maintenance of standards and objectivity, review and evaluate reports, publish final estimates of potential gas.

POTENTIAL GAS COMMITTEE

J. C. Herrington, President/General Chairman
James K. Curry, Chairman, Board of Directors
David A. Rochester, Secretary
George C. Grow, Jr., Chairman, Editorial Committee
Charles J. Crowley, Chairman, Committee on Definitions and Procedures
Richard J. Burgess, Chairman, Time and Site Committee

Under direction of Potential Gas Agency, outline study, establish criteria and methods, designate and instruct Area Work Committees, supervise, coordinate and compile estimates made by Work Committees.

Membership --
(a) President/General Chairman and Regional Vice Presidents -- appointed by Potential Gas Agency and approved by A.G.A. Gas Supply Committee.
(b) Area Work Committee Members.
(c) Potential Gas Agency -- Director -- Ex officio.
(d) Technical Advisors and Honorary Technical Advisors.
(e) Department of Energy, Energy Information Administration, Federal Energy Regulatory Commission, Department of Interior Geological Survey, Bureau of Mines and such other governmental agencies as the Gas Supply Committee and Potential Gas Agency shall approve--one nonvoting observer each, and alternates, if desired.
(f) Gas Research Institute, Institute of Gas Technology, Natural Gas Supply Association and Electric Power Research Institute--one nonvoting observer each, and alternates, if desired.
(g) Association of American State Geologists, NARUC and IOCC--one nonvoting observer each, and alternates, if desired.
(h) Canadian and Mexican natural gas industry--one nonvoting observer each, and alternates, if desired.
(i) A.G.A., staff--one representative.
(j) One Pipeline and one Distributor representative to be designated by the Gas Supply Committee.
(k) Others appointed by Gas Supply Committee and approved by Potential Gas Agency.

REGIONAL VICE PRESIDENTS
AND AREA WORK COMMITTEES

Number of committees and assignments as designated by Potential Gas Committee and approved by Potential Gas Agency. Under direction of Potential Gas Committee, prepare estimates for given assignments.

Membership --
(a) Chairman--appointed by President/General Chairman of Potential Gas Committee and approved by Potential Gas Agency.
(b) Sufficient producer and other qualified members to insure proper representation for given assignment--appointed by Chairman of Work Area.
(c) At least one Pipeline and one Distributor representative to be designated by Gas Supply Committee.

EASTERN REGION

Jeffery V. Morris, Vice President
Porter J. Brown, Assistant Vice President

Area	Chairman
Atlantic	Porter J. Brown
North Central	Curtis L. Lundy
Gulf Coast	J. C. Kucewicz, Jr.
Mid-Continent	Billy D. Brown

WESTERN REGION

Robert D. Habbit, Vice President
D. Keith Murray, Assistant Vice President

Area	Chairman
Rocky Mountain	H. O. Woodbury
Pacific	K. E. Wainwright
Alaska	Bruce I. Clardy

Figure 8. Organization of potential gas supply studies

Gas Supply Committee of the American Gas Association

The membership of the Gas Supply Committee consists of representatives of member companies of the American Gas Association selected by the Chairman of the Board and approved by the Board of Directors of the American Gas Association.

The scope of the Committee is to coordinate, motivate and make recommendations to the Board of American Gas Association as to the areas in which A.G.A. should become more active in the development of adequate gas supply for both short-term and long-term. In addition, the Committee undertakes special projects, where necessary, to evaluate industry gas supply programs. The Gas Supply Committee oversees the work of the Potential Gas Agency.

The primary duties and responsibilities of the Gas Supply Committee with relation to potential gas studies include the following:

a. Establishing policy and objectives.

b. Providing required financial support.

c. Maintaining liaison with industry and industry organizations.

d. Selecting the Potential Gas Agency.

e. Approving the appointment of the President/General Chairman and Regional Vice Presidents of the Potential Gas Committee by the Potential Gas Agency.

f. Appointing pipeline and distributor representatives to the Potential Gas Committee as may be necessary or advisable.

g. Appointing such other members and observers to the Potential Gas Committee as may be necessary or advisable.

h. Assisting in procurement of qualified manpower to staff properly the Potential Gas Committee and the Area Work Committees.

The Gas Supply Committee of the American Gas Association takes no part in the work or the deliberations of the Potential Gas Committee or its sub-committees. The Gas Supply Committee does not participate in the studies leading to the estimates of potential supply of natural gas, and it neither approves nor disapproves the definitions and procedures, the estimates, or the report.

Potential Gas Agency of the Colorado School of Mines

The Potential Gas Agency functions under the direction of the Vice President for Academic Affairs of the Colorado School of Mines. The School, with the approval of the Gas Supply Committee, appoints staff personnel to the Potential Gas Agency.

The Potential Gas Agency is supported by the American Gas Association. The American Gas Association is free, however, to take independent views of the operations and the studies produced by the Agency and its committees. The Agency is charged with the maintenance of scientific standards and objectivity of studies and publishes the reports of the Potential Gas Committee. The Agency appoints the President/General Chairman and Regional Vice Presidents of the Potential Gas Committee, approves the appointment of members, representatives and observers to the Potential Gas Committee and the chairmen of all sub-committees.

The Potential Gas Agency includes the following:

a. A Director, appointed by and responsible to the Colorado School of Mines.

b. Such additional staff personnel as may be required.

c. Members of the faculty of the Colorado School of Mines or other qualified individuals who may, from time to time, provide such professional services as the Director of the Potential Gas Agency and the President/General Chairman of the Potential Gas Committee may determine necessary or desirable for discharging the duties of the Potential Gas Agency and the Potential Gas Committee.

The primary duties and responsibilities of the Potential Gas Agency include the following:

a. Approving criteria and methods established by Potential Gas Committee, including protecting the confidentiality of Potential Gas Committee data.

b. Insuring maintenance of the highest scientific standards and objectivity in Potential Gas Committee studies and reports.

c. Reviewing and evaluating reports prepared by the Potential Gas Committee.

d. Publishing, distributing and publicizing reports of final estimates and other pertinent reports prepared by the Potential Gas Committee so as to assure the widest possible distribution and to promote understanding of them.

e. Further develop mutual understanding among the segments of the gas industry by helping the Gas Supply Committee unite the industry behind the potential gas studies.

f. Help improve industry-government relations in the public interest looking toward maximum acceptance and usefulness of potential gas studies.

g. Fulfill the professional obligation to publish technical papers concerning new techniques and knowledge gained.

h. Appointing President/General Chairman and Vice Presidents of Potential Gas Committee, with approval of Gas Supply Committee.

i. Approving appointment by Gas Supply Committee of other members, representatives and observers to the Potential Gas Committee.

j. Approving appointment of President/General Chairman of Potential Gas Committee, of Chairman of each Work Committee and chairmen of other committees.

k. Conduct the work of the Potential Gas Agency, in the public interest, in a manner which will enhance the stature of the Colorado School of Mines.

l. Adhere to the highest standards of objectivity.

The Colorado School of Mines may pursue other research, and individuals from the Agency may be involved in other research, consulting and preparation and publication of papers in their professional fields, so long as these activities do not involve a conflict of interest nor invalidate the objectivity of the Agency.

Potential Gas Committee

The Potential Gas Committee comprises members, representatives and observers from the producing, pipeline and distribution branches of the gas industry, together with observers from the American Gas Association, the Department of Energy, the Federal Energy Regulatory Commission, the U.S. Geological Survey, the National Association of Regulatory Utility Commissioners, the Interstate Oil Compact Commission, the Bureau of Mines, the Gas Research Institute, Institute of Gas Technology, Association of American State Geologists, Electric Power Research Institute, Natural Gas Supply Association and representatives from Canada.

The President/General Chairman of the Potential Gas Committee is assisted by the two Regional Vice Presidents and by a Board of Directors, composed of senior members of the Potential Gas Committee, including past chairmen. It is the function of the Board of Directors to advise the President/General Chairman on policy matters.

An Editorial Committee is charged with approving the content of the report of the Potential Gas Committee.

The Definitions and Procedures Committee has the responsibility of reviewing and recommending to the membership of the Potential Gas Committee any proposed changes in the definitions and procedures used in the estimation of potential gas resources.

Membership of the Potential Gas Committee specifically includes the following:

a. President/General Chairman of Potential Gas Committee.
b. Secretary of Potential Gas Committee.
c. Regional Vice Presidents and Assistant Vice Presidents.
d. Chairman of each Area Work Committee.
e. Chairman of Board of Directors.
f. Chairman of Editorial Committee.
g. Chairman of Committee on Definitions and Procedures.
h. Chairman of Time and Site Committee.
i. Director of the Potential Gas Agency, ex officio.
j. Observer from the Federal Energy Regulatory Commission.
k. Observers from the Department of Energy.
l. Observer from the Geological Survey, United States Department of the Interior.
m. Observer from the Bureau of Mines, United States Department of the Interior.
n. Observer from National Association of Regulatory Utility Commissioners.
o. Observer from the Interstate Oil Compact Commission.
p. Observer from Natural Gas Supply Association.
q. Observer from Association of American State Geologists.
r. Observer from the Gas Research Institute.
s. Observer from the Institute of Gas Technology.
t. Observer from Electric Power Research Institute.
u. Representative from the natural gas pipeline industry.
v. Representative from the natural gas distribution industry.
w. Representative from the American Gas Association.
x. Observer from the Canadian natural gas industry and observer from the Mexican natural gas industry.
y. Technical Advisors and Honorary Technical Advisors.
z. Representatives and observers from other organizations may be recommended for appointment by the Potential Gas Agency Director and approved by the Gas Supply Committee.

All members of the Potential Gas Committee, except those specifically designated as observers, are considered as voting members of the Potential Gas Committee. Observers are invited and encouraged to participate in discussion of items brought before the Potential Gas Committee but do not have a vote in the determination of policy and procedure. Alternates to representatives and observers may be appointed.

Candidates for Committee President/General Chairman and Vice Presidents normally will be geologists or persons with geology background from the academic community, pipelines, independent firms, gas utilities or producing companies. Retired or semi-retired gas industry people are not excluded from consideration.

Officers of the Potential Gas Committee and Area Work Committees are appointed as outlined in the Organizational Chart (fig. 8). Normally they serve for a period of one report. They are eligible for reappointment, however, for one additional report period. In calculating eligibility for reappointment, a partial term of office shall not be counted. This policy shall not operate to disqualify a member from longer service by reason of elevation in the organization. In other words, the two-term limitation shall apply to each position held, considering each membership or officership on a work committee or any committee as a separate position.

All officers, regional vice presidents and the pipeline and distribution representatives appointed by the American Gas Association Gas Supply Committee shall be subject to the two-report limit. Exceptions must be recommended by the appropriate Committee Chairman and the Potential Gas Agency Director and approved by the American Gas Association Gas Supply Committee.

Technical Advisors include persons who have special knowledge of the occurrence of natural gas or the natural gas industry and whose expert advice will contribute to the successful performance of the Committee's assignments. Past Chairmen of Work Areas and Past Regional Vice Presidents of the Potential Gas Committee will be appointed as Technical Advisors if they are willing to continue to participate in the work of the Committee. The appointment of Technical Advisors is approved by the Gas Supply Committee upon recommendation by the Potential Gas Agency Director. Technical Advisors are appointed for the preparation of a specific PGC report. Their appointment may be continued indefinitely but is subject to review and approval at the time of organization of the Potential Gas Committee for each succeeding report.

The designation of Honorary Technical Advisor may be given to such persons as have performed exceptional service to the Potential Gas Committee and whose continued participation and advice are desirable for the continued successful operation of the Committee. Honorary Technical Advisors are permanent voting members; their appointment is recommended by the Board of Directors and approved by the Potential Gas Agency Director and the Gas Supply Committee.

Observers from sponsoring associations, governmental agencies and other cooperating groups serve at the discretion of these organizations and are not subject to the two-report policy.

The primary duties and responsibilities of the Potential Gas Committee include the following:

a. Outlining the scope and coverage of the estimates of potential natural gas supply.
b. Establishing criteria and methods for estimation of potential natural gas supply and other pertinent studies.
c. Designating Work Areas and Special Projects.
d. Appointing the Chairman of each Area Work Committee (by action of President/General Chairman of Potential Gas Committee).
e. Approving appointment of other members of each Area Work Committee who are appointed by the Chairman of each Area Work Committee (by action of President/General Chairman of Potential Gas Committee).
f. Instructing Area Work Committees.
g. Supervising, coordinating, advising, reviewing, evaluating, approving and compiling estimates and such other assignments as may be given to committees.
h. Preparing reports of final estimates and such other reports as may be pertinent.
i. Submitting reports of final estimates and other pertinent reports to the Potential Gas Agency and counseling with Director regarding publication and distribution of such report.

Area Work Committees

Seven Area Work Committees are the backbone of the Potential Gas Committee. Each of the Work Committees has the responsibility of developing an estimate of the potential supply of natural gas in a particular part of the United States. Following the system long used by the petroleum industry, each Area Work Committee is assigned geologically significant areas (without specific regard to state lines) in which the Committee members have expert working knowledge. These Committee members with their fund of information (often confidential), are the source of knowledge and judgment for estimating the undiscovered gas supply in each area. Because geologic rather than geographic divisions are used, publication of estimates by individual states is not feasible.

The membership of Area Work Committees consists of employees and consultants associated with the producing, pipeline and distribution segments of the gas industry--as well as qualified personnel from State and Federal Agencies and educational institutions.

For administrative purposes, the Area Work Committees are grouped together in two regions: Eastern and Western. Each of these regions is supervised by a Regional Vice President who coordinates activities of the Area Work

Committees within his jurisdiction and works with the Potential Gas Committee President/General Chairman in order to assure that there is an open flow of communication in both directions, and that the established techniques for resource estimation are being followed by the Area Work Committees.

Membership of Area Work Committees includes the following:

a. Chairman of each Area Work Committee.
b. An appropriate number of qualified working members deemed necessary by the Chairman of each Work Committee to insure the most objective estimates of potential supply of natural gas in the respective area assigned. Work Committee members are individuals from the natural gas and oil industries and other individuals who are qualified by their knowledge and experience to make estimates of potential supply of natural gas. The individuals are selected for each area because they have a close, working knowledge in all aspects of natural gas exploration and production.
c. At least one qualified representative on each Area Work Committee from the natural gas pipeline industry, appointed by the Gas Supply Committee.
d. At least one qualified representative on each Area Work Committee from the natural gas distribution industry, appointed by the Gas Supply Committee. (This requirement is waived for the Alaska Committee.)

The Chairman and Vice Chairman of each Area Work Committee are subject to the two-report limit. Exceptions must be recommended by the Regional Vice President, approved by the Potential Gas Committee President/General Chairman and the Potential Gas Agency Director, and reported to the Gas Supply Committee, and only after receiving a clearance letter from the member's employer.

Other members of the Area Work Committees, appointed by the Area Chairman, will normally participate in the preparation of two successive reports. Service beyond the preparation of two reports may be continued if necessary to maintain adequate expertise and continuity on the Area Work Committee. Continuation of service beyond two reports must be recommended by the Area Chairman and approved by the Regional Vice President, the Potential Gas Committee President/General Chairman, and the Potential Gas Agency Director.

The primary duties and responsibilities of Area Work Committees include the following:

a. Appointing appropriate number of qualified working members to insure proper representation of various sectors of the industry and objectivity for the best estimates of potential supply of natural gas for assigned areas (by action of Chairman of each Area Work Committee).
b. Estimating quantity of potential supply of natural gas in working areas designated by the Potential Gas Committee pursuant to the guidelines and parameters established by the Potential Gas Committee, and approved by the Potential Gas Agency, and such other studies as may be assigned by the Potential Gas Committee.
c. Peforming such other assignments as may be made in the respective area assigned by the Potential Gas Committee regarding such estimate.

Each member of each Area Work Committee will submit his estimates of potential supply of natural gas and such other assignments as may be given to him in his assigned sub-area to the Chairman and other members of his committee for review, evaluation and approval.

Since the type and quantity of available information upon which to base estimates of potential natural gas supply vary widely from area to area, the Area Work Committee members use varied approaches in making their estimates. Inasmuch as the individual members work with private information obtained on a confidential basis from many sources, their working papers are not revealed in detail to anyone, including other members of the same Area Work Committee or others in the Potential Gas Committee. Without such confidential information, the Potential Gas Committee could not perform its task; therefore, each member, observer or representative of the Work Committees is aware of and must respect the confidential nature of the data made available to him and of the estimates and other assignments prepared or reviewed by the Area Work Committees and the Potential Gas Committee.

Standing Committees of the Potential Gas Committee

Board of Directors

The Board of Directors shall serve as the administrative coordinating committee for the Potential Gas Committee. It shall consider and discuss any matters of policy which are brought to its attention and shall make recommendations to the Potential Gas Committee regarding changes in policy. It shall act on behalf of the Potential Gas Committee on matters of urgency which arise between regularly scheduled meetings of the Potential Gas Committee. It may also be empowered to act on behalf of the Potential Gas Committee on matters designated by the Potential Gas Committee. At such times as vacancies occur in the following offices, the Board of Directors shall either act as a nominating committee to recommend suitable candidates or appoint a nominating committee from among its membership: PGC President/General Chairman, Regional Vice Presidents, Secretary of the PGC and Chairman of the Board of Directors.

Chairmen of PGC standing committees, with the exception of the Board of Directors, will be appointed by the PGC President/General Chairman, subject to approval by the Board of Directors. All actions of the Board of Directors will be reported to the membership of the Potential Gas Committee at their next regularly scheduled meeting and shall be subject to review and approval by the Potential Gas Committee.

Membership

Chairman, elected from the membership of the Potential Gas Committee by the voting members of the PGC at a regular meeting. Nominations for Chairman will be made by the Board of Directors and nominations will also be received from the floor. Normally, the Chairman will be elected at the fall meeting following publication of the biennial PGC report and will serve for two years. Vacancies will be filled by election at the next regular PGC meeting, following the same procedure and a Chairman so elected will serve for the remainder of the unexpired term. In the absence of the elected Chairman, the President/General Chairman of the Potential Gas Committee will serve as Chairman of the Board of Directors.

The following ex officio voting members: PGC President/General Chairman, PGC Regional Vice Presidents, Secretary of the PGC, Potential Gas Agency Director, Chairmen of Standing Committees, representatives appointed to the PGC from the natural-gas pipeline and natural-gas distribution industries, representative from the Canadian gas industry, representative from the American Gas Association.

In addition, a maximum of five voting Technical Advisors may be appointed by the Potential Gas Committee President/General Chairman, subject to approval by the Potential Gas Agency Director.

Editorial Committee

The Editorial Committee will review and approve the editorial content and format of PGC reports. They will work closely with the Potential Gas Agency in the publication of all official publications of the Potential Gas Committee.

Membership

Chairman, appointed by the Potential Gas Committee President/General Chairman, and approved by the Board of Directors. Six members of the Potential Gas Committee, appointed by the Editorial Committee Chairman, with approval of the PGC President/General Chairman. PGC President/General Chairman, ex officio; Potential Gas Agency Director, ex officio.

Committee on Definitions and Procedures

This Committee has the responsibility of reviewing and recommending to the membership of the Potential Gas Committee any proposed changes in the definitions and procedures used in the estimation of potential gas resources. Proposals to be reviewed by this Committee may be submitted by any member of the Potential Gas Committee. The Committee will further review estimates of potential gas resources made by other organizations which come to the attention of the Committee and may, from time to time, as deemed appropriate, prepare publications dealing with the comparison of the work of the Potential Gas Committee with that of other organizations. The Committee on Definitions and Procedures will also serve as liaison with the U.S. Geological Survey Resource Appraisal Group and other such organizations as are involved in the work of estimation of potential gas resources.

Membership

Chairman, appointed by the PGC President/General Chairman and approved by the Board of Directors. Four members of the Potential Gas Committee, appointed by the Chairman of the Committee on Definitions and Procedures, with approval of the PGC President/General Chairman. PGC President/General Chairman, ex officio; PGA Director, ex officio.

Time and Site Committee

This Committee will select an appropriate location and date for each national PGC meeting which will serve best the needs of the Committee. Once the site and date of each meeting have been selected by the Committee, the Potential Gas Agency will be charged with the responsibility of completing the arrangements for the meeting. The Time and Site Committee will also coordinate any regional meetings which are scheduled by Regional Vice Presidents in order that the dates of such meetings shall not be in conflict.

Membership

Chairman, appointed by the PGC President/General Chairman and approved by the Board of Directors. Three members of the Potential Gas Committee, appointed by the Chairman of the Time and Site Committee and approved by the PGC President/General Chairman. Regional Vice Presidents, ex officio; PGC President/General Chairman, ex officio; PGA Director, ex officio.

Communications

Communication Between Committees

The formal channel of communication shall be from the Area Work Committees to the Potential Gas Committee to the Potential Gas Agency to the American Gas Association Gas Supply Committee and vice versa.

Public Communication

Members of the Potential Gas Agency, the Potential Gas Committee and the Area Work Committees are encouraged to publicize and explain their work. These efforts should be limited to explaining the methodology used, comparative methodology and the strengths and limitations of the work. When acting as spokesmen for the Committee, members shall refrain from interpreting study results in terms of national policy needs or required industry incentives. Members who are called upon to make talks and write papers on behalf of the Committee should submit texts to the Potential Gas Agency for comment and policy review.

MEMBERSHIP OF THE POTENTIAL GAS AGENCY AND POTENTIAL GAS COMMITTEE

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Ladine Rintoul, Staff Assistant

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AXFORD, Donald W. (8): Pres., D. W. Axford & Assoc. Ltd, Calgary, Canada 1977-. Pres., D B & K Oils Ltd., Calgary 1977-. Pres., Columbia Basin Energy Corp., U.S. 1982-. Petro-Canada, V. Pres. Expl. & Prod. 1976-77. Mobil Oil (Canada & U.S.), V. Pres. Expl. & Dir. 1948-76. Dir.: Audax Gas & Oil Ltd., Highridge Expl. Ltd., Lutheran Life Ins. Soc. Canada. Mem. Am. Assn. Petrol. Geol., Assn. Prof. Engrs., Geol. & Geophys. Alberta, Canadian Soc. Petrol. Geol., Canadian Petrol. Assn., Geol. Assn. Canada, Soc. Econ. Paleon. & Min., PGC Hon. Tech. Adv., Observer - Canada.

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[+] Number in parenthesis following name indicates number of Potential Gas Committee reports in which member participated.

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(Hastings, MI) 1972-75. MI Consolidated Gas Co., Staff Geol. (Detroit, MI) 1969-72. Mem. Am. Assn. Petrol. Geol., MI Basin Geol. Soc. (Past Pres., V. Pres. and Treas.), MI Oil and Gas Assn. (Bd. Dir.), PGC North Central Area Comm.

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BENDLER, E. Perry (10): Supv., Geol., Geol. & Land Serv., The East Ohio Gas Co., Cleveland, OH 1955-. Mem. Am. Assn. Petrol. Geol. (Comm. on Statistics of Drlg.), Assn. Prof. Geol. Scientists (Cert. #2473), No. OH Geol. Soc., OH Geol. Soc., OH O&G Assn., PGC Tech. Adv., Atlantic Area Comm.

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BOYD, Ellis R. Jr. (2): Office of Oil & Gas, Div. of Reserves & Nat. Gas, DOE/EIA, Chief, Reserves and Prod. Branch Deputy Dir., Office of Oil & Gas Information System, Washington, DC 1977-. Federal Power Comm., held various positions in Area Rate Div. including Deputy Dir., Planning & Develop. Div.; Bureau of Nat. Gas and Chief, Planning & Spec. Proj. Branch. Marathon Oil Co., various production engineering and supervisory posts, Gulf Coast area 1954-66. Mem. Soc. Petrol. Engrs., PGC Observer - EIA.

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DIEHL, Laurence A. (2): Expl. Mgr., Century Oil and Gas Corp., Englewood, CO 1981-. Cities Service Co., Expl. positions (Billings, MT, Casper, WY, Denver, CO) 1953-81. Mem. Rocky Mtn. Assn. Geol., KS Geol. Soc., WY Geol. Soc., PGC Rocky Mtn. Area Comm.

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FEEMSTER, Lee T. Jr. (9): Geol. Consultant, Abilene, TX 1974-. Texas Pacific Oil Co., Expl. Geol. & Develop. Geol. 1955-74. Stanolind (Amoco), Expl. Geol. 1951-55. Mem. Am. Assn. Petrol. Geol., Abilene Geol. Soc., West Texas Geol. Soc., PGC Mid-Continent Area Comm.

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HABBIT, Robert D. (6): Habbit Enterprises, El Paso, TX 1983-. El Paso Natural Gas Co., Mgr. Reservoir Engineering (El Paso, TX) 1978-83; Mgr. Reservoir Studies 1978; Coor. Reservoir Geol. 1977-78; Staff Geol. 1966-77. Ind. Geol. (Houston, TX) 1965-66. El Paso Natural Gas Co., Sr. Reservoir Geol. (Houston) 1957-65. Sohio Petroleum Co., Geophysicist/Geol. (Gulf Coast-Rocky Mtns.) 1954-57. Mem. Am. Assn. Petrol. Geol. (CPG #186), Am. Inst. Prof. Geol. (Cert. #2489), Am. Inst. Min., Met. & Petrol. Engr., Soc. Expl. Geophysicists, Rocky Mtn. Assn. Geol., El Paso Geol. Soc., PGC Bd. Dir., V. Pres. - Western Region, Time & Site Comm., Rocky Mtn. Area Comm.

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HOWARD, Richard H. (4): Geol., Oil & Gas Sec., IL State Geol. Surv., Champaign, IL 1958-. Phillips Petrol. Co., Geol. 1957. U.S. Geol. Surv., CO Plateau Uranium Expl. Proj., Geol. 1954. Mem. Am. Assn. Petrol. Geol., IL Geol. Soc., PGC North Central Area Comm.

HUMPHRIES, E. Floyd (10): Consultant, NAPECO Inc., Houston, TX 1981-; Asst. V. Pres. 1980-81; Natural Gas Pipeline Co. of Am., Mgr. Geol. (Expl. & Contracted Supply) (Houston, TX) 1954-80. Claud B. Hamill, Independent 1949-54. Tidewater Assoc. Oil Co. 1946-49. Mem. Am. Assn. Petrol. Geol. (Cert.), Assn. Prof. Geol. Scientists (Cert.), Houston Geol. Soc., PGC Bd. Dir., Hon. Tech. Adv., Time & Site Comm.

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Geol. (Detroit, MI) 1981-84; ANR Production Co., Mgr. Northeast Dist. (Troy, MI) 1980-81; American Natural Gas Production Co. (Detroit, MI) 1978-80; Michigan Natural Resources, V. Pres. Opr. MI Basin 1976-78; Michigan Consolidated Gas Co., Dir., Geol. Expl. & Gas Acquisition 1964-78; Mgr. Geol. Dept. (Grand Rapids, MI) 1959-64. Gulf Oil Corp., Zone Geol. & Staff Asst. Explor. Mgr., MI, IL & Anadarko Basins 1949-59. Mem. Am. Assn. Petrol. Geol., Assn. Prof. Geol. Sci., MI Basin Geol. Soc., MI Oil & Gas Assn., PGC Tech. Adv.

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MATHENY, J. Paul (1): Expl. Geol., Celsius Energy Co., Farmington, NM 1982-. Gulf Oil Corp., Geol. (Midland, TX) 1981-82. U.S. Geol. Surv., Geol. Field Asst. (Salt Lake City, UT) 1979-81. El Paso Expl. Co., Summer Geol. (Farmington, NM) 1978; Oilfield roustabout 1975-77 (summers). Mem. Am. Assn. Petrol. Geol., Four Corners Geol. Soc., NM Geol. Soc., Soc. Econ. Paleon. & Min., West TX Geol. Soc., PGC Rocky Mtn. Area Comm.

McELROY, John H. (3): Sr. Coord., Expl. & Prod. Serv. Dept., Texaco Inc., Bellaire, TX 1977- Expl. Coord. 1972-77; Midland Asst. Div. Mgr. 1969-72; Houston Div. Geol. 1967-69; Houston Asst. Div. Geol. 1961-67; Geol. 1958-61. Seaboard Oil Co., Geol., Asst. Dist. and Dist. Geol. 1951-58. Gulf Oil Corp., Surf. and Subsurf. Geol. 1948-51. Mem. Am. Assn. Petrol. Geol., PGC Gulf Coast Area Comm.

McGARRAH, Joe E. (5): Chief Geol., ONEOK Expl. Co., Tulsa, OK 1981-; Sr. Geol. 1978-81; Staff Geol. 1973-78. National Assn. Petrol. Co., Reg. Geol. 1956-73. Frost Geophysical Co., Geophysics Training 1954-56. U.S. Air Force Intelligence, Photo Interpreter 1952-54. U.S. Geol. Surv., Topographic Engr. (Rolla, MO) 1951-52. Mem. Am. Assn. Petrol. Geol., Gas Men's Assn. OK, Tulsa Geol. Soc., PGC Mid-Continent Area Comm.

McLAUGHLIN, C. K. (2): Mgr., Permian Supply Eval., Northern Nat. Gas Co., Midland, TX 1984-; Reg. Mgr. Sup. Eval. & Reserve Mgmt. Permian Basin 1980-84. ANR Production Co., Staff Res. Engr. (Houston, TX) 1978-80. Forest Oil Co., Div. Res. Engr. (Midland, TX) 1960-78. H. S. Cole, Resident Mgr. (Santa Domingo, Dom. Rep.) 1958-60. Amoco, Dist. Res. Engr. (Denver, CO) 1951-58. Mem. Nat. Gas Soc., Soc. Petrol. Engrs., TX Prof. Engr., PGC Mid-Continent Area Comm.

McMULLIN, Robert H. (3): Reg. Supv., Resource Eval., Minerals Management Service, Anchorage, AK 1982-. U.S. Geol. Surv., Br. Oil & Gas Res., Geol. (Anchorage) 1979-82; Area Geol. 1976-79; OCS Eval. Supv. 1975-76; Geophysicist, Conservation Div. 1971-75. Chevron U.S.A. Inc., Expl. Geol. & Geophysicist (CA, WA, OR, NV, AK) 1955-71. Mem. AK Geol. Soc., Am. Assn. Petrol. Geol., Geophy. Soc. AK, Soc. Explor. Geophys., PGC Alaska Area Comm.

McPEEK, Larry A. (3): Cons. Geol., Denver, CO 1972-. Koch Exploration, Expl. Mgr. Rocky Mtn. Div. (Denver, CO) 1969-72. Pan American Petroleum (Amoco), Dist. Oper. Geol. (Denver, CO and New Orleans, LA) 1962-69. Mem. Am. Assn. Petrol. Geol., Rocky Mtn. Assn. Geol., WY Geol. Assn., PGC Rocky Mtn. Area Comm.

**MEHRING, Edmund K. (4): Pres. & C.E.O., Fuel Resources Gathering Inc. and Exec. V. Pres. & Ch. Oper. Officer, Fuel Resources Inc. (Mem. Bd. of Dir. both companies), Brooklyn, NY 1980-; Brooklyn Union Gas Co., Mgr. Expl. and V. Pres., Fuel Resources Inc. 1977-80; Mgr. Spec. Proj. 1971-77; Mgr. Tech. Serv. Dept. 1969-71; Asst. Mgr. Manuf. Dept. 1965-69; Gen. Supt., Greenpoint Works, Manuf. Dept. 1963-65. Mem. Am. Gas Assn. (Merit Award), BHP Energy, Inc. OK (Bd. Dir.), Ind. Oil & Gas Assn. of NY, Ind. Oil and Gas Assn. WV, Natl. Assn. Corrosion Engrs.-Corrosion Specialist, NY State Prof. Engrs., Soc. Adv. of Mgmt., Soc. Gas Oper., Tri-State Well Service WV (Bd. Dir.), PGC Atlantic Area Comm.

MILLER, Richard D. (1): Supv. Petrol. Engr., Chief, Sect. Helium Res. Eval., U.S. Bureau of Mines, Amarillo, TX. Mem. PGC Observer - BUMINES.

MORRIS, Jeffery V. (6): Mgr., Res. Geol., Transco Energy Co., TGPL, Houston, TX; Reg. Geol., Dist. Geol., Sr. Geol., Geol. 1961-. Sun Oil Co., Geol. (Houston, TX) 1959-61. El Paso Nat. Gas Co., Geol. (New Orleans) 1956-59. Gulf Oil Corp., Geol. (New Orleans) 1954. Mem. Am.

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Assn. Petrol. Geol., Houston Geol. Soc. (Pres. 1978-79), Nat. Gas Men of Houston, PGC Bd. Dir., V. Pres. - Eastern Region, Time & Site Comm., Gulf Coast Area Comm.

MOUNCE, Paul (9): Expl. Mgr., Petrosil Resources Inc., Dallas, TX 1980-. Ind. Petrol. Geol. 1978-80. Maynard Oil Co., Ch. Geol. 1974-78. Lone Star Gas Co., Staff & Corporate Development. Texas Pacific Oil Co., Dist. Geol. Fifteen Oil Co., Dist. Geol. Warren Petrol. Corp., Dist. Geol. Mem. Am. Assn. Petrol. Geol., Am. Inst. Min., Met. & Petrol. Engrs., PGC Tech. Adv., Mid-Continent Area Comm.

MURDY, Richard J. (10): Retired, Ocean Springs, MS 1984-. CNG Producing Co., Pres. (New Orleans, LA) 1979-84; V. Pres. (Clarksburg, WV) 1973-78; Consolidated Natural Gas Co., Asst. to Chmn. of Bd. 1968-73; Asst. Treas. (New York, NY) 1963-68; Asst. to Pres. 1957-63. New York State Natural Gas, Chief Geol. (Pittsburgh, PA) 1952-57. Consolidated Gas Underground Storage Engr. (Pittsburgh, PA) 1948-52. Mem. Am. Assn. Petrol. Geol., Am. Gas Assn., Am. Inst. Petrol. Geol., Geol. Soc. Am., So. Gas Assn., Soc. Petrol. Engrs., PGC Bd. Dir., Hon. Tech. Adv.

MURRAY, D. Keith (9): Cons. Geol., Lakewood, CO 1983-. Energetics, Inc., Mgr. Spec. Proj. (Englewood, CO) 1981-83. Colorado Sch. Mines Research Inst. (Golden, CO) 1979-81. CO Geol. Surv. (Denver, CO) 1973-79. Coronado Oil Co., Cons. Geol. (Denver) 1969-73. Sinclair Oil Corp. (Denver) 1966-69. Cons. Geol. (Denver) 1962-66. Clark Oil & Refining Corp. (Denver) 1960-62. Ind. Geol. (Los Angeles, CA) 1959-60. Manabi Expl. Co. (Ecuador, SA) 1956-58. Shell Oil Co. (CA, UT, NV, LA) 1953-56. Mem. Am. Assn. Petrol. Geol. (Rocky Mtn. Sec. Councillor, Energy Min. Div., House of Delegates, Natl. AAPG V. Pres. 1979-80), Am. Inst. Prof. Geol., CO Sci. Soc., Denver Coal Club, Geol. Soc. Am., Rocky Mtn. Coal Min. Inst., Rocky Mtn. Petrol. Pioneers, WY Geol. Assn., PGC Bd. Dir., Asst. V. Pres. - Western Region, V. Chmn. Rocky Mtn. Area Comm.

MYERS, Eugene (1): Dist. Devel. Geol., Union Oil Co. of CA, Lafayette, LA. Mem. PGC Gulf Coast Area Comm.

NEUMEYER, Charles L. (7): Energy Consultant, Brooklyn, NY 1984-. The Brooklyn Union Gas Co., Sr. Officer, Reg. Affairs & Sup. Planning Dept., Marketing & Adv. Dept., Urban Affairs Dept., Corporate Comm. Sec., Govt. Affairs Sec., Explor. Activities, Subs. Activities - FRI, GEI, MDC 1971-84; V. Pres., New Bus. Dept. & Publ. Rel. & Adv. 1968-71; Rate Dept., Asst. V. Pres. 1962-68; Mgr. 1957-62; Asst. Mgr. 1954-57; Res. Asst. 1946-54; Acctg. Dept. 1942; Cadet Engr. 1941. Mem. Assn. Gas Dist. (Mem. and former Chmn. Exec. Comm., mem. Program Rev. Comm., former mem. and Chmn. Nom. Comm.), Brooklyn Club, Gasmen's Roundtable, Interstate Nat. Gas Assn., Soc. Gas Lighting, former mem Am. Gas Assn. (Mem. Gas Supply Comm., Industry Commun. Comm., former mem. and Chmn. Rate Comm.), PGC Edit. Comm., Hon. Tech. Adv.

NEWSOM, Max (3): Expl. Adv., Gulf Oil Expl. & Prod. Co. (35 years of geological experience in various domestic locations), New Orleans, LA 1949-85. Mem. Am. Assn. Petrol. Geol., Am. Petrol. Inst. (Delta Chapter), New Orleans Geol. Soc., Soc. Expl. Geophys., Southeastern Geophys. Soc., PGC Atlantic Area Comm.

PEDIGO, Norris E. (1): Div. Reservoir Engr., Nat. Gas Pipeline Co., Houston, TX 1972-; Dist. Res. Engr. 1969-72; Dist. Res. Engr. (Amarillo, TX) 1967-69; Res. Engr. 1957-66; Devel. Engr. (Chicago, IL) 1956-57; Meter Station Oper. (Fairbanks, TX) 1953-55. Mem. Am. Gas Assn. (Reserves Sub-Committee), Nat. Gas Men Houston, Soc. Petrol. Engrs., Reg. Prof. Engr. TX, PGC Mid-Continent Area Comm.

**PERKINS, Kenneth R. (2): Sr. Gas Buyer, Cabot Corp., Amarillo, TX 1984-. Westar Transmission Co., Sr. Gas Contracts Rep. (Amarillo) 1982-84. Tejas Gas Corp., Dist. Mgr. - TX Offshore (Houston) 1981-82. Northern Nat. Gas Co., Sr. Gas Contracts Rep. (Houston) 1978-81. MI WI Pipeline Co., Staff Gas Contracts Rep. (Houston) 1975-78. Mem. Nat. Gas Men Houston, Nat. Gas Soc. N. TX, Nat. Gas Soc. Permian Basin, Panhandle Nat. Gas Soc., PGC Mid-Continent Area Comm.

PLATT, Jeremy (2): Proj. Mgr., Energy Resources Program, Electric Power Research Inst., Palo Alto, CA 1974-. Mem. Am. Assn. Petrol. Geol. (Energy Min. Div.: Pacific Sec. Councillor and Comm. on Nuclear Minerals), Geol. Soc. Am., PGC Observer - EPRI.

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POWERS, Richard B. (4): Geol., U.S. Geol. Surv., Br. Oil & Gas, Lakewood, CO 1974-. Consultant (Denver, CO) 1971-74. Bolyard & Assoc., V. Pres. (Denver) 1968-71. Tenneco Oil, Sr. Staff Geol. (Houston, TX) 1967-68; Dist. Geol. (Casper, WY) 1965-67; Dist. Mgr. (Pittsburgh, PA) 1962-65; Reg. Geol. (Casper & Denver) 1959-62. Petrobras, Geol. (Belem, Brazil) 1958-59. Pure (Union) Oil Co., Geol. (Grand Junction, CO) 1952-58. Mem. Am. Assn. Petrol. Geol. (Membership Comm), Rocky Mtn. Assn. Geol., WY Geol. Assn., Canadian Soc. Petrol. Geol., PGC Rocky Mtn. Area Comm.

RAGSDALE, Tom R. (5): Sterling Drilling & Prod. Co., Inc., Charleston, WV 1981-. Ray Resources, Ch. Geol. 1973-81. Consolidated Gas Supply Corp., Devel. Geol. (Clarksburg, WV) 1966-73. McCullough Tool Co., Engr. Geol. 1962-66. Mem. Appalachian Geol. Soc. (Past V. Pres.), PGC Atlantic Area Comm.

RASSINIER, E. A. (10): Independent, Houston, TX 1982-. Trunkline Gas Co., Dir. Resource Planning 1964-81; Ch. Petrol. Engr. 1953-64. Phillips Petrol. Co. (Prod. Dept.), Supv. Petrol. Engr. (Bartlesville, OK) 1951-52; Reg'l. Reservoir Engr. (Houston) 1947-50; Div. Reservoir Engr. (Oklahoma City, OK) 1946; Petrol. Engr. (Bartlesville, Borger, Kansas City) 1942-43. Mem. Am. Assn. Petrol. Geol., Am. Inst. Min., Met. & Petrol. Engr., Soc. Petrol. Engrs., Houston Engr. & Scientific Soc., Houston Geol. Soc., Reg. Prof. Engr. (TX), PGC Hon. Tech. Adv., Gulf Coast Area Comm.

RICHART, John M. (5): Dist. Expl. Geol., Union Oil Co. of CA, Jackson, MS 1975-. Pure Oil Co. (prior to merger with Union), Expl. Geol. (IL, MI and Appalachian Basins) 1969-75. Mem. Am. Assn. Petrol. Geol., Jackson Geophys. Soc., MS Geol. Soc., PGC Gulf Coast Area Comm.

**ROCHESTER, David A. (6): Asst. Mgr., Gas Supply, Public Service Elec. & Gas Co., Newark, NJ 1981-; Fuels Planning Engr. 1977-81; Nat. Gas Engr. 1971-77; Engr. 1967-71; Cadet Engr. 1966-67. River Gas Co., Engr. (Marietta, OH) 1964-66. Mem. Am. Gas Assn. (Task Force), Am. Inst. Min., Met. & Petrol. Engr., Assoc. Gas Dist. (Chmn. Operating Comm.), Gas Distrs. Information Serv., Inc. (Officer & Bd. Dir.), NJ Gas Assn. (Supply & Rates Comm.), Petrol. Expl. Soc. NY, Soc. Petrol. Engrs., PGC Sec., Bd. Dir., Exec. Comm., Edit. Comm., Comm. Def. & Proc., Gulf Coast Area Comm.

SANBORN, Albert F. (4): Geol. Consultant, Littleton, CO 1984-. Buckhorn Petrol. Co., Frontier Div., Expl. Mgr. (Denver, CO) 1981-84. Cons. Geol. 1978-80. Chevron U.S.A., Sr. Geol. 1963-78; Div. Stratigrapher (Salt Lake City, UT) 1959-63; Dist. Stratigrapher 1955-59; Geol. Stratigrapher 1954-55; Geol.-Stratigrapher (Los Angeles, CA) 1952-54. Mem. Am. Assn. Petrol. Geol., Am. Inst. Petrol. Geol., Rocky Mtn. Assn. Geol., PGC Rocky Mtn. Area Comm.

SATTERFIELD, Ira R. (2): Geol. & Chief of Oil & Gas/Subsurface Sect., MO Geol. Survey, Rolla, MO 1981-; Oil & Gas Geol. 1979-81; Stratigrapher & Areal Geol. 1967-79. Amoco Prod. Co., Expl. Geol. 1965-67. Mem. Am. Assn. Petrol. Geol., Assn. MO Geol., PGC North Central Area Comm.

SCHELDE, Don (1): Southern Nat. Gas Co., Houston, TX. Mem. PGC Gulf Coast Area Comm.

SELINGER, Keith (1): Pioneer Production, Amarillo, TX. Mem. PGC Gulf Coast Area Comm.

SEXTON, R. Michael (2): Gen. Mgr. Geol. Serv., Natl. Fuel Gas Sup. Corp., Buffalo, NY 1981-; Asst. Supt. (Division) 1969-81; Staff Engr. 1966-69; Field Petrol. Engr. 1961-66. Mem. Am. Gas Assn., Am. Petrol. Inst., IOGA-NY (Board), Environ. Protection Agency U.I.C. Adv. Board, PA Oil & Gas Assn. (Board), Gov. Cuomo's Adv. Board on Oil, Gas & SOLN Min. (NY), PGC Atlantic Area Comm.

SHARER, John C. (3): Dir., Nat. Gas Supply Research, Gas Research Institute, Chicago, IL 1982-; Asst. Dir., Unconven. Nat. Gas 1978-82. Consultant (Farmington, ME) 1975-78. Institute of Gas Technology, Supv. (Chicago, IL) 1972-75. Procon Inc., Process Engr. Dept. (Des Plaines, IL) 1971-72. Mem. Am. Chem. Engrs., Prof. Engr. (IL, ME), PGC Observer - GRI.

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SHERMAN, Carl W. (9): Assoc. Prof. Petrol. & Nat. Gas Engr., PA State Univ., University Park, PA 1975-. Honeoye Storage Corp., Mgr. Opr. 1974-75. NY State Public Serv. Comm., Principal Systems Planner, Gas Div. 1971-74; NY State Div. Min. Resources, Dir. 1964-71. IL Geol. Surv., Head Petrol. Engr. Sec. 1957-64. JB & M Inc., Tex-Canadian Oil Corp., Marathon, The California Co. 1948-57. Mem. Am. Gas Assn., Am. Petrol. Inst., Soc. Petrol. Engrs., Fed. Power Comm. Tech. Adv. Comm. (Nat. Gas Surv.), Interstate Oil Compact Comm. (1957-74), PGC Atlantic Area Comm.

SISSON, Alexander (6): Sr. Geol., Union Oil Co. of CA, Anchorage, AK 1966-. Esso Standard Oil, Sr. Geol. (Bogota) 1964-66; Geol. (Guatemala) 1961-63; Geol. (Havana) 1957-60. Carter Oil Co., Geol. (Denver) 1951-56. Mem. Am. Assn. Petrol. Geol. (Environ. Comm.), AK Geol. Soc. (Pres. 1977), PGC Alaska Area Comm.

SMITH, Charles E. (8): Pres., Transworld Gas Systems, Inc., Whittier, CA 1971-. Union Oil Co. of CA, Mgr. Nat. Gas and Gas Liquids Dept. (Los Angeles, CA) 1967-70. Mem. PGC Tech. Adv.

SMITH, H. Gifford (1): Ark-La Expl. Co., Shreveport, LA. Mem. PGC Gulf Coast Area Comm.

SPENCER, C. W. (2): Prog. Chief, Onshore Basin Studies, Western Tight Gas Reservoirs & Proj. Chief, Land Classification-Western U.S. Oil and Gas, Br. Oil and Gas Resources, U.S. Geol. Surv., Denver, CO 1974-. Texaco Inc., Rocky Mtn. Area, Dist. Geol. & Mgr., Expl. & Devel. Lab. (Denver) 1959-74. U.S. Geol. Surv., Min. Deposits Br. (Washington, DC) 1955-57; Water Resources Div. 1957-58. Mem. Am. Assn. Petrol. Geol., Geol. Soc. Am. (Fellow), Rocky Mtn. Assn. Geol., Soc. Econ. Paleon. & Min., Soc. Petrol. Engrs., Soc. Prof. Well Log Analysts, WY Geol. Assn., PGC Tech. Adv.

STOLLAR, Richard L. (1): Sr. Geol., Columbia Gas Trans. Corp., Charleston, WV 1981-; Geol. I 1979-81; Geol. 1976-79. Mem. Am. Assn. Petrol. Geol., Geol. Soc. Am., Appalachian Geol. Soc., Lic. Prof. Geol. State of VA #203, PGC Atlantic Area Comm.

*STRACKE, Kenneth J. (5): Dir., Prod., Northwest Pipeline Corp., Salt Lake City, UT 1975-. Cons. (Salinas, CA) 1974-75. Union Oil Co. of CA 1954-1974. Mem. Am. Gas Assn. (Expl. & Prod. Comm.), Reg. Prof. Engr. UT, Soc. Petrol. Engrs. (Bd. Dir. 1983-), PGC Bd. Dir., Edit. Comm., Rocky Mtn. Area Comm.

**SULLIVAN, Richard A. (8): Pres., So. County Gas and Bristol & Warren Gas Co., Hingham, MA 1959-. Boston Transit System, Exec. & Consulting Engr. 1949-58. Detroit Transit System, Gen. Mgr. 1945-48. City of Detroit, Public Util. Anal. 1942-45. U.S. Engr., Cons. Engr. 1941-42. MA Dept. Public Util., Elec. Engr. 1937-41. Mem. Am. Gas Assn., NE Gas Assn., Harvard Engr. Soc., MA Soc. Prof. Engrs., NH Bar Assn., PGC Gulf Coast Area Comm.

THOMPSON, Wayne M. (3): Chief, Gas Supply Branch, Office of Pipeline & Producer Regulation, Fed. Energy Regulatory Comm., Washington, DC 1967-. Geol. Cons. (Oil & Gas) (El Dorado, AR) 1961-67. Robbins Petrol. Corp., Geol.-Engr. (Longview, TX) 1959-61. Petroleum Inc., Geol. (Shreveport, LA) 1958-59. McAlester Fuel Co. (Magnolia, AR) 1954-58. Mem. PGC Observer - FERC.

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TONNSEN, John J. (2): V. Pres. Expl., General Hydrocarbons, Inc., Billings, MT 1981-. The Montana Power Co., Sr. Expl. Geol. (Billings, MT) 1975-81. Shell Oil Co., Gen. Expl. Attorney (New York and Denver) 1967-73. Pan American Petrol. Co., Expl. Field Geol. (MT, ID, CO and UT) 1960-62. Mem. Am. Assn. Petrol. Geol., MT Geol. Soc., MT & CO State Bar Assn., Fed. Energy Bar Assn., PGC Rocky Mtn. Area Comm.

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(Chmn. OR Sec.; Mem. Gas Pipeline Standards Comm.; Fellow Award 1980), Am. Soc. Metals, Am. Gas Assn. (LNG Legis. Task Force, Ch. Corrosion Comm. 1968-69), Pacific Coast Gas Assn. (Mem. Gas Sup. Comm., Past Chmn. Codes & Const. Comm., Leadership Awards 1975), Natl. Assn. Corr. Engrs. 1975-76 (Chmn. OR Sec. 1965, West. Reg. Div. 1962-64, West. Reg. Engr. Year 1966), N.A.C.E. 6-man Task Force (wrote corrosion sec. of D.O.T. Pipeline Safety Reg.), N.A.C.E. Cert. Corr. Engr., Pacific Coast Gas Assn. (Oper. Sec. Gen. Chmn. 1980-81, Gen. V. Chmn. 1979-80), Gas Research Inst. (Mem. Indus. Tech. Adv. Comm.), PGC Pacific Area Comm.

VAUGHAN, William L. (5): Gen. Mgr. Reserves Eval. Dept., Texas Eastern Pipelines, Houston, TX 1973-. Texas Eastern Trans. Corp., Asst. Mgr., Reserves and Deliverability 1972-73; Jr. Petrol. Engr.-Engr. (Gas Supply Dept.) 1957-72. Mem. Am. Gas Assn. (Chmn., Underground Gas Storage Comm.), Soc. Petrol. Engrs., Nat. Gas Men Permian Basin, PGC Rocky Mtn. Area Comm.

WAINWRIGHT, Kenneth E. (3): Sr. Geol. Assoc., ARCO Oil & Gas Co., Bakersfield, CA 1979-; Sr. Geol. 1977-79; Geol. 1970-77; Geol. (Roswell, NM) 1967-70; Geol. (Denver, CO) 1962-67. Mem. Am. Assn. Petrol. Geol., San Joaquin Geol. Soc., PGC Chmn. - Pacific Area Comm.

WATERMAN, Douglas R. (7): Mgr. Devel. Geol., West. Reg. Prod. Dept., Chevron U.S.A. Inc., Concord, CA 1984-. Standard Oil Co. of CA, Geol. Cons./Adv., Foreign Oper. Staff (San Francisco, CA). Chevron U.S.A. Inc., Dist. Supt. Sacramento-San Joaquin Dist; Dist. Supt., Coastal Dist., So CA; Dist. Geol., Ventura Dist. & West. Dist., So. CA; Area Geol., Santa Barbara Channel, CA, So. CA; Seismic Crew Rep., LA & Sacramento Basins & Salton Trough, CA, Cook Inlet, AK, So. CA; Dist. Geol., Salinas & So. San Joaquin Basins, So. CA; Geol., Subsurf. Geol., San Joaquin, Salinas & Santa Maria Basins, CA, So. CA; Geol., Oil Field Study & Second Recovery, San Joaquin Basin, CA, So. CA; Geol., Well Site Geol., Central & Southern CA, So. CA. Mem. Am. Assn. Petrol. Geol., No. CA Geol. Soc., CA Reg. Geol. #695, PGC Pacific Area Comm.

WEAGANT, Frank E. (2): Chmn. of the Board, Nahama & Weagant Energy Co., Bakersfield, CA 1981-; Cons. Geol. & Pres. 1965-81. Franco Western Oil Co., Head Geol. & Geol. 1955-65. Chevron U.S.A. Inc., Geol. 1951-55. Mem. Am. Assn. Petrol. Geol., PGC Pacific Area Comm.

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WIGAL, James M. (4): Dist. Expl. Mgr., Adobe Oil & Gas Corp., Pittsburgh, PA 1981-. The Peoples Nat. Gas Co., Geol./Geophys./Expl. Mgr. 1975-81. Dept. of Energy/Bureau of Mines, Geol. (Morgantown, WV) 1974-75. Mem. Am. Assn. Petrol. Geol., Soc. Econ. Paleon. & Min., Soc. Econ. Geol., Soc. Prof. Well Log Anal., PGC Atlantic Area Comm.

WILKINS, A. A. (4): V. Pres., TCPL Resources, Ltd., Calgary, Canada 1982-. TransCanada PipeLines, V. Pres., Gas Supply Dept., Alberta Div.; Mgr. of Reserves, Chief Geol., Geol. 1965-82. Hudson's Bay Oil and Gas, Expl. Geol. 1960-65. Mem. Canadian Soc. Petrol. Geol., Am. Assn. Petrol. Geol., Assn. Canadian Inst. Min. & Met., Ontario Nat. Gas Assn., PGC Observer - Canada.

WILSON, Gary D. (2): Mgr., Anadarko Supply Eval., Northern Natural Gas Co., Tulsa, OK. Mem. PGC Mid-Continent Area Comm.

WOODBURY, H. O. (2): Div. Geol. Rocky Mtn. Div., Chevron U.S.A. Inc., Denver, CO 1981-. Standard Oil Co. of CA (Indonesia) 1979-81; (New Orleans, LA) 1972-81; (Tripoli, Libya) 1971-72; New Orleans, LA) 1965-71; Chevron Research Corp. (LaHabra, CA) 1964; (New Orleans, LA) 1955-64; (Casper, WY and Denver, CO) 1946-55. Mem. Am. Assn. Petrol. Geol. (Cert.), Rocky Mtn. Assn. Geol., PGC Chmn. - Rocky Mtn. Area Comm.

WOODSON, James C. (1): V. Pres., Expl., Samedan Oil Corp., Ardmore, OK. Mem. PGC Mid-Continent Area Comm.

WRIGHT, Darrell (1): Mgr. Geol., Southern Nat. Gas Co., Houston, TX 1978-; Sr. Geol., Geol. 1967-77. Associated Oil & Gas Co., Geol. (Houston, TX) 1963-66. Texas Gas Utilities Corp., Geol. (Del Rio, TX) 1959-62. Mem. Am. Assn. Petrol. Geol., Houston Geol. Soc., PGC Gulf Coast Area Comm.

ZARESKI, Gordon K. (3): Sr. V. Pres., H. Zinder & Assoc., Washington, DC 1979-. Department of Energy, Office of Oil & Gas Information System, Dir. (Washington, DC) 1977-79. Federal Power Comm., Bureau of Nat. Gas, Ch. of Planning & Development (Washington, DC) 1969-77. Mem. Am. Assn. Petrol. Geol., Geol. Soc. Washington, DC, PGC Tech. Adv.

WESTERN REGION
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PACIFIC
ROCKY MOUNTAIN
NORTH CENTRAL
MID-CONTINENT
GULF COAST
ATLANTIC
P-960-961 PACIFIC OFFSHORE (0-200m)SHELF (200-1000m)SLOPE
P-600
P-610 EASTERN COLUMBIA BASIN
OREGON-WASHINGTON COASTAL BASINS, OKANOGAN PROVINCE
P-570 SWEETGRASS ARCH, CENTRAL MONTANA UPLIFT
Northern Thrust Belt
P-575 MONTANA FOLDED BELT
P-580 SNAKE RIVER BASIN
P-500 WILLISTON BASIN
P-515 BIG HORN BASIN
P-510 POWDER RIVER BASIN
Central Thrust Belt
WIND RIVER BASIN
P-520
P-590 WYOMING-UTAH-IDAHO THRUST BELT
P-530 GREATER GREEN RIVER BASIN, HANNA-LARAMIE BASINS
P-620 GREAT BASIN, SIERRA NEVADA, KLAMATH MTNS., SOUTHERN OREGON
SACRAMENTO BASIN
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P-535 DENVER BASIN, CHADRON ARCH, LAS ANIMAS ARCH
P-550 PARADOX BASIN
P-650 SAN JOAQUIN BASIN
CALIFORNIA COASTAL BASINS
P-660
P-630 SOUTHEASTERN CALIFORNIA BASINS
P-565 PLATEAU PROVINCE, BLACK MESA BASIN
P-555 SAN JUAN BASIN
P-545 SAN LUIS BASIN, SAN JUAN MTNS., SIERRA GRANDE UPLIFT, LAS VEGAS-RATON BASIN
P-560 SOUTHERN BASIN & RANGE PROVINCE
P-400 CENTRAL KANSAS UPLIFT, SALINA BASIN, NEMAHA ANTICLINE, SEDGWICK BASIN
P-420 PALO DURO BASIN, ANADARKO BASIN, AMARILLO-WICHITA UPLIFT
P-440 PERMIAN BASIN
P-430 FT. WORTH BASIN, BEND ARCH, STRAWN BASIN
P-410 ARKOMA BASIN
P-240 WISCONSIN ARCH, SIOUX UPLIFT, IOWA SHELF
Midcontinent Rift
P-260 FOREST CITY BASIN, CHEROKEE BASIN
P-250 LINCOLN ANTICLINE, OZARK UPLIFT
P-200 MICHIGAN BASIN
P-220 ILLINOIS BASIN
P-210 CINCINNATI ARCH
P-230 UPPER MISSISSIPPI EMBAYMENT
P-150 BLACK WARRIOR BASIN
P-120 APPALACHIAN BASIN
Eastern Thrust Belt
P-130 PIEDMONT-BLUE RIDGE PROVINCE
P-110 ATLANTIC COASTAL BASIN
P-100 NEW ENGLAND PROVINCE, ADIRONDACK UPLIFT
P-910-911 ATLANTIC OFFSHORE (0-200m)SHELF (200-1000m)SLOPE
P-320 EAST TEXAS BASIN
P-300 LOUISIANA-MISSISSIPPI-ALABAMA SALT BASINS
P-310 LOUISIANA GULF COAST BASIN
P-330 TEXAS GULF COAST BASIN
P-940-941 TEXAS OFFSHORE (0-200m)SHELF (200-1000m)SLOPE
P-935-936 LOUISIANA OFFSHORE (0-200m)SHELF (200-1000m)SLOPE
P-930-931 EASTERN GULF COAST OFFSHORE (200-1000m)SLOPE (0-200m)SHELF
P-140 SOUTH GEORGIA-PENINSULAR FLORIDA SEDIMENTARY PROVINCE
P-915-916 WEST FLORIDA OFFSHORE (0-200m)SHELF (200-1000m)SLOPE
CANADA
MEXICO
GULF OF MEXICO

1984 ESTIMATED POTENTIAL SUPPLY OF NATURAL GAS

(Trillion Cubic Feet - Most Likely)

AREA	PROBABLE	POSSIBLE	SPECULATIVE
ATLANTIC	24.3	8.8	51.1
NO. CENTRAL	0.1	2.3	10.3
GULF COAST	54.8	96.0	38.2
MID – CONTINENT	46.3	88.2	58.4
ROCKY MTN.	48.3	53.0	33.4
PACIFIC	1.9	15.6	15.7
TOTAL LOWEF 48	175.7	263.8	207.1
ALASKA	9.1	29.1	99.2
TOTAL UNITED STATES	184.8	292.9	306.2

Plate 1
POTENTIAL GAS COMMITTEE
NATURAL GAS MAP OF THE UNITED STATES
December 31, 1984

- ■ AREAS OF GAS PRODUCTION INCLUDING GAS ASSOCIATED WITH OIL
- ▨ AREAS IN WHICH SEDIMENTARY ROCKS ARE EXPOSED AT THE SURFACE OR ARE PRESENT AT DEPTH AND COVERED AT THE SURFACE BY EXTRUSIVE IGNEOUS ROCKS
- ☐ AREAS IN WHICH INTRUSIVE IGNEOUS ROCKS OR METAMORPHIC ROCKS ARE EXPOSED AT THE SURFACE
- LIMITS OF SEDIMENTARY BASINS AS RECOGNIZED BY THE POTENTIAL GAS COMMITTEE, DASHED WHERE INFERRED
- –15,000– CONTOUR LINE INDICATING THICKNESS OF SEDIMENTS

25 0 25 50 75 100 125 150 175 200 MILES
25 0 25 50 75 100 125 150 175 200 KILOMETERS

Western Thrust Belt

The Western Thrust Belt, especially the central portion which is located along the Wyoming-Idaho border, has become a major target for exploration. Significant gas fields have been discovered in southwestern Wyoming and northern Utah. While the eastern boundary of this belt is fairly well defined by the limits of thrust faults, the western boundary is much more nebulous. Some interpretations extend the Western Thrust Belt southeastward from southern Nevada through Arizona, southwestern New Mexico, westernmost Texas and into Mexico. At the present time, the only areas within the Thrust Belt in which estimates of potential resources of natural gas have been made are the northern, central, and southern portions indicated on the map. Because of lack of positive confirmation of the extention of the Thrust Belt south of Utah and the lack of data on potential source rocks, reservoir rocks, and trapping mechanisms, no estimate of any potential resource of natural gas has been made for this area.

This map prepared by Terra Graphics to accompany Potential Gas Committee report, Potential Supply of Natural Gas in the United States (December 31, 1984). Copies available from Potential Gas Agency, Colorado School of Mines, Golden, Colorado 80401. Phone (303) 279-4320.

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Eastern Overthrust Belt

Recent exploratory activity and geophysical data have led to the interpretation of an Eastern Overthrust Belt extending from Canada southward into Georgia and Alabama. In the western portion of this belt, sedimentary rocks are exposed at the surface. In the eastern portion, sedimentary rocks are believed to exist beneath metamorphic rocks. Preliminary estimates of natural gas potential for the Eastern Overthrust Belt are included in the estimates reported for Atlantic Area.

- ☐ Exposed Sediments
- ☐ Concealed Sediments

R 8765-1 (2)

Plate 2
POTENTIAL GAS COMMITTEE
NATURAL GAS MAP OF ALASKA

December 31, 1984

1984 ESTIMATED POTENTIAL SUPPLY OF NATURAL GAS IN ALASKA
(Trillions of Cubic Feet – Most Likely)

PROBABLE - 9.1 · POSSIBLE - 29.1 · SPECULATIVE - 99.2

■	AREAS OF GAS PRODUCTION INCLUDING GAS ASSOCIATED WITH OIL
☐	AREAS IN WHICH SEDIMENTARY ROCKS ARE EXPOSED AT THE SURFACE OR ARE PRESENT AT DEPTH AND COVERED AT THE SURFACE BY EXTRUSIVE IGNEOUS ROCKS
☐	AREAS IN WHICH INTRUSIVE IGNEOUS ROCKS OR METAMORPHIC ROCKS ARE EXPOSED AT THE SURFACE
	LIMITS OF SEDIMENTARY BASINS AS RECOGNIZED BY THE POTENTIAL GAS COMMITTEE, DASHED WHERE INFERRED
	SEDIMENTARY BASINS BELIEVED NOT TO HAVE POTENTIAL FOR NATURAL GAS
	CONTOUR LINE INDICATING THICKNESS OF SEDIMENTS

This map prepared by Te[illegible]aphics to accompany Potential Gas Committee report, Potential Supply of Natural Gas in the United States (December 31, 1984). Copies available from Potential Gas Agency, Colorado School of Mines, Golden, Colorado 80401. Phone (303) [illegible]

50 0 50 100 150 MILES
50 0 50 100 150 KILOMETERS
ARCTIC OCEAN
CHUKCHI SEA
CHUKCHI SHELF
BEAUFORT SEA
BEAUFORT SHELF
POINT BARROW
ICY CAPE
POINT HOPE
U.S.S.R.
CANADA
U.S.A.
P-701 NORTH SLOPE PROVINCE
P-702 BROOKS RANGE PROVINCE
P-703 YUKON FLATS-KANDIK BASIN
P-704 ALASKA INTERIOR BASINS
P-705 NORTHERN GULF OF ALASKA PROVINCE ONSHORE
P-706 SOUTHEASTERN ALASKA PROVINCE
P-707 COOK INLET/SUSITNA PROVINCE ONSHORE
P-708 ALASKA PENINSULA & SHELIKOF ONSHORE
P-709 ALASKA PENINSULA-BRISTOL BAY ONSHORE
P-710 ALEUTIAN ISLANDS
P-971 BEAUFORT SEA SHELF (0-200m)
P-972 BEAUFORT SEA SLOPE (200-1000m)
P-973 CHUKCHI SHELF (0-200m)
P-974 NORTON BASIN
P-975 HOPE BASIN
P-979 ST. MATTHEW-BETHEL BASIN SHELF (0-200m)
P-980 SOUTHWEST BERING SEA SLOPE (>1000m)
P-981 NAVARIN BASIN SHELF (0-200m)
P-982 NAVARIN BASIN SLOPE (200-1000m)
P-983 ST. GEORGE BASIN SHELF (0-200m)
P-984 ST. GEORGE BASIN SLOPE (200-1000m)
P-985 BRISTOL BAY BASIN SHELF (0-200m)
P-987 SHUMAGIN-KODIAK SHELF (0-200m)
P-988 SHUMAGIN-KODIAK SLOPE (200-1000m)
P-989 ALEUTIAN SHELF (0-200m)
P-990 ALEUTIAN SLOPE (200-1000)
P-991 NORTHERN GULF OF ALASKA SHELF (0-200m)
P-992 NORTHERN GULF OF ALASKA SLOPE (200-1000m)
P-993 SOUTHEASTERN ALASKA SHELF (0-200m)
P-994 SOUTHEASTERN ALASKA SLOPE (200-1000m)
P-995 COOK INLET BASIN OFFSHORE
BROOKS RANGE
BAIRD MTNS.
ENDICOTT MOUNTAINS
PHILIP SMITH MOUNTAINS
BRITISH MOUNTAINS
RICHARDSON MOUNTAINS
SEWARD PENINSULA
NORTON BASIN
HOPE BASIN
KOYUKUK BASIN
YUKON FLATS BASIN
KANDIK BASIN
NULATO HILLS
KUSKOKWIM MTNS.
ALASKA RANGE
TANANA BASIN
COPPER RIVER BASIN
WRANGELL MTNS.
CHUGACH MOUNTAINS
ST. ELIAS MOUNTAINS
COAST MOUNTAINS
MACKENZIE MOUNTAINS
FRANKLIN MTNS.
CASSIAR MOUNTAINS
ROCKY MOUNTAINS
NORTHWEST TERRITORIES
YUKON TERRITORY
BRITISH COLUMBIA
BERING SEA
NAVARIN BASIN
ST. GEORGE BASIN
BETHEL BASIN
BRISTOL BAY BASIN
ALEUTIAN ISLANDS
ALASKA PENINSULA
GULF OF ALASKA
TERTIARY PROVINCE
PACIFIC OCEAN
ST. LAWRENCE ISLAND
ST. MATTHEW ISLAND
NUNIVAK ISLAND
ST. PAUL ISLAND
ST. GEORGE ISLAND
UNIMAK ISLAND
UMNAK ISLAND
UNALASKA ISLAND
KODIAK ISLAND
AFOGNAK ISLAND
TRINITY ISLANDS
CHIRIKOF ISLAND
SHUMAGIN BASIN
SANAK BASIN
MONTAGUE ISLAND
BARANOF ISLAND
PRINCE OF WALES ISLAND
QUEEN CHARLOTTE ISLANDS
ATTU ISLAND
NEAR ISLANDS
AGATTU ISLAND
KISKA ISLAND
RAT ISLANDS
AMCHITKA ISLAND
TANAGA ISLAND
ADAK ISLAND
ATKA ISLAND
AMLIA ISLAND
SEGUAM ISLAND
ANDREANOF ISLANDS
200 METERS
1000 METERS

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